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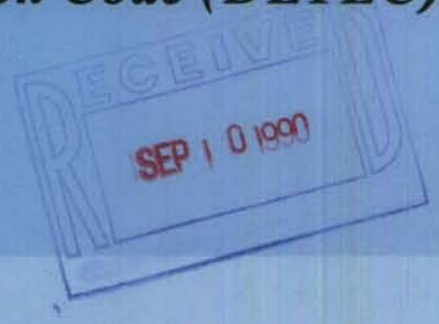
Conceptual Specification for Defensive Technology Evaluation Code (DETEC)



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CONTENTS

1.	ABSTRACT	1-1
2.	INTRODUCTION	2-1
3.	DESIGN APPROACH	3-1
4.	SCENARIO EXAMPLE	4-1
5.	LEVEL 0 DATA FLOW AND DESCRIPTIONS	5-1
6.	LEVEL 1 DATA FLOW AND DESCRIPTIONS	6-1
7.	LEVEL 2 & 3 DATA FLOW AND DESCRIPTIONS	7-1
8.	DATA DEFINITIONS	8-1
9.	APPENDIX	9-1
	A. Structured Analysis Conventions	9-2
	B. Naming Conventions	9-4
	C. Alternative Proposals	9-5

CONCEPTUAL SPECIFICATION

for

DEFENSIVE TECHNOLOGY EVALUATION CODE (DETEC)

by

Ronald D. Christman, Arthur L. Dana, Dale B. Henderson,
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1. ABSTRACT

The Defensive Technology Evaluation Code (DETEC) is being developed to assess the potential of a realistically diverse assortment of strategic defense and offense assets deployed on all sides in possible global conflict. Principal applications of the code will be to study the roles of the various weapon technology concepts being explored for strategic defense. Technology requirements and sensitivities will be studied in the context of complete wars built up from many individual one-on-one engagements. DETEC will also provide an important vehicle with which to develop and test various possible algorithms for battle management and for communications and control.

The DETEC simulation features a wide span of capabilities. It includes each important object with separate modular representations of each replica decoy, re-entry vehicle, missile, submarine, satellite, etc. Such complete offensive and defensive inventories are employed on all sides of an arbitrarily many-sided conflict. The one-on-one engagement modules are statistical processes based upon accurate physical models. Damage to individual assets is simulated by operating parameters that may be continuously varying, giving simulated performance from full to zero capability.

Countermeasures are explicitly included. Each sensor, weapon, and control and communications system is modeled by a library of code modules allowing the user to balance the needs of his problem, the fidelity levels, and the computational costs. Stresses on the operating environment include both natural (sun, moon, storms) and battle-driven (jamming, weapon, nuclear) effects. DETEC is event driven, with both instantaneous and time-extended events allowed. Conflicts between extended events and instantaneous or other extended events are identified and explicitly accommodated. Separate files are maintained for the "real" data, the perceived data of each combatant, and that of each combatant's subsystems.

The modular code structure is developed for efficient execution on our Cray-X computer. A true restart capability allows a simulation to be restarted with or without modifications, which may include arbitrary interventions. Convenient user interaction and powerful graphics-based postprocessing are important design functions. Although we draw on the experience of existing military simulations, DETEC is a new product that relies heavily on our experience with efficient supercomputer codes for the design of nuclear weapons.

Our design procedure has utilized both the formal methods and concepts of structured program design. The substance of this document describes the design specifications (data flow, data definitions, and control flow).

Ideas and suggestions for this document have been incorporated from a large group of people including Laboratory consultants, other employees, researchers at many military operations research establishments, and their contractors. For this help and encouragement we are grateful.

ABSTRACT

2. INTRODUCTION

The Defensive Technology Evaluation Code (DETEC) simulation is an analytical tool for general application to systems studies within the strategic defense program. The code is intended to be capable of simulating engagements between any arbitrary strategic offensive and defensive systems, given code modules describing the set of weapons effects of interest against assets of interest. In order to do this, DETEC has been designed as a very general simulation system with scenario-dependent coding confined to modular code subunits that may be "plugged into" the general DETEC framework. It is intended that a large catalog of the individual modules will be acquired, and it is hoped that many of them will be contributed by members of the community outside the DETEC team and outside Los Alamos National Laboratory. The capability to simulate virtually any arbitrary engagement requires treatment of the entire earth and its near vicinity (at least out to geosynchronous orbit) and the ability to simulate and/or keep track of a large number of assets. Estimates range from some thousands of objects in a limited engagement to upwards of fifty thousand in a full-scale exchange.

The corresponding code may therefore be thought of as a large, specialized data base code, with the state of the "world" being represented in several million words of computer memory. Several computer processes are invoked to set up this data base, others are invoked to move it forward in time, while still others are used to report the progress to the users both interactively and through various postprocess reports.

DETEC simulation capability allows a user to investigate the efficacy of weapons, sensor, battle management, and communications systems, as well as the effect of policy and strategy. The sensitivity of a system's effectiveness to technology assumptions and design and deployment parameters can be studied under full campaign conditions. Both natural (e.g., weather, electromagnetic environment) and engagement-induced stresses (e.g., nuclear effects, electronic warfare) are simulated. Countermeasures can be explicitly simulated. The modular nature of individual assets and physics simulators allows them to be written to the fidelity required for a particular application without modifying any other part of the DETEC system. Medium to high-fidelity battle management simulation requires the concept of "perceived worlds" as opposed to the "real world." This refers to the inevitable incompleteness and inaccuracy of the information available to a battle manager–his "perceived world" as derived from his sensor. In contrast, the code will maintain a data file containing an accurate (by definition) description of each object included in the simulation. This file is termed the REAL_WORLD.

Each object description is a data structure that has been named a STATE_VECTOR. DETEC STATE_VECTORS are hybrid structures–they contain a complete parameterized description of an object's state and kinematics (like a quantum mechanical state vector), and they also contain an evaluation, for a particular instant in time, of a subset of the possible descriptive variables. This subset will always include position and may include other quantities, depending on the class of object described.

The volume of space from the surface of the earth out to some user-defined limiting radius may in DETEC be divided into some number of angle and radius limited sectors. This, like the evaluation of the position, is a calculational efficiency feature. The sector in which an object is located will be stored in the object's state vector and changed as updated positions require. The sector locations are used to limit the number of state vectors that must be considered for position-dependent calculations (such as what a sensor can see or with what a weapon effect will interact). The positions data in the state vector can be used as is for relatively slowly moving objects, or it can be updated to the exact current simulation time if the physics and fidelity require it.

Geographical and environmental data will also be referenced by sector. Environmental influences at a particular point will be treated as caused by two additional components; a slowly varying component that is calculated at routine update intervals and parameterized by sector, and a rapidly varying component that

is calculated from individual "source" state vectors as needed.

The processes simulated by DETEC may be considered to fall into two classes: those whose time evolution is (relatively) easily parameterized and predicted and those whose time evolution is potentially complex. Examples of the first class of processes are both powered and free motion, the development and evolution of a localized weather system, and the expansion of a nuclear fireball. Examples of the second class are the functioning of a sensor, weapon, battle manager or communications installation, or the interaction of a weapons effect with an asset. Processes of the first type are not explicitly simulated by DETEC; their behavior is built into pertinent subroutines by algorithms using state vector parameters to provide specific evaluations as needed. Changes in these parameters (analogous) to a transition between quantum mechanical states) are explicitly simulated. Processes of the second type compose the bulk of DETEC's simulation task. These calculations are performed by individual asset and physics simulation modules chosen from the DETEC module catalog. These simulation calculations are triggered by a precalculated instruction termed an EVENT.

An EVENT is a data structure containing a specification of what asset or physical process is to be simulated and when it is to occur. EVENTs can be created at code initialization or directly by the user, but, as a rule, they are constructed by asset or physics simulation modules themselves.

DETEC calculates what subsequent occurrences are required (as in the case of battle managers) or caused by a particular simulated action, and EVENTs to trigger the simulations of these processes are constructed. EVENTs may be treated as either instantaneous (being of negligible duration) or extended. Instantaneous events are marked by a single EVENT. Extended events require an EVENT to mark the beginning of the process and a second EVENT to mark its end. It is possible for an extended event to occur over a period during which the state of an asset involved in the process is being changed by another event. Such situations have been termed conflicts and are identified and resolved by one of two methods. If the structure of the conflict allows and the specific code modules are able, a conflict may be resolved by saving copies of the changing state vector. This information would then be used to calculate, at the simulation time corresponding to the end of the event, the process simulation for the entire time period of the event. Otherwise, the conflicting events are divided into a number of time steps suitable for the characteristic times of the processes involved, and the state vectors are used as constants during each time step.

The time-ordered series of EVENTs is termed the EVENT_Q, and the simulation proceeds from event to event in the queue, with no calculational investment in the parameterized "easy" processes between EVENTs.

The EVENT_Q also contains EVENTs that are, using the above definition, "nonevents." These are markers that trigger periodic displays, logging functions, and updates of the evaluated portion of the state vector and environmental data. Their inclusion as "nonevents" or "pseudo-events" allows a simple control structure for the main execution loop.

The general DETEC code structure reflects a division by function into five main units. The user interface and code initialization are performed by the code MANAGER. The user interface accommodates interactive graphical setup, checkout, and monitoring functions. The setup of a simulation requires specification of the order-of-battle (numbers, characteristics, and employment of assets); battle manager "policy" instructions (parameter sets tailored to the design of the particular module selected); physics and asset module selection consistent with the preceding natural environment parameters; and any specific events desired by the user. This may be accomplished by commands entered directly from the terminal or by assigning a file containing a list of commands (an INFILE). Setup may be "from scratch" or based on any other partial

or complete DETEC problem specification defined through a restart file or one or more INFILEs.

A restart modification is conceptually identical to a referee-type intervention, and, in DETEC, this intervention mechanism will allow user intervention in virtually all aspects of the simulation.

The code initialization functions performed by the MANAGER include construction of the REAL_WORLD and PERCEIVED_WORLDS files, as well as the initial EVENT_Q and setup of code and system parameter tables. Module and data libraries will be assigned.

Running and monitoring parameters, such as selection of a graphics display, how frequently to update the display, the type and frequency of data logging, and how often to write restart dumps will be part of a simulation run setup. The user also specifies the set of optional variables to be written, in addition to a large set of standard variables, into postprocessor files. These data provide periodic "snap-shots" of the simulation. From these files, the postprocessor can provide the following: graphical or tabular data for specific simulation times, time histories of simulated quantities, and comparisons of these data for different times, variables, or different DETEC simulation runs. For convenience, the postprocessor has the same user interfaces as the main DETEC code, with all common function commands being identical.

Control functions for the DETEC simulation execution are centralized in the code, EXECUTIVE. The EXECUTIVE sequentially processes the events in the EVENT_Q, identifying and calling the appropriate code unit to execute that particular event. For each extended or instantaneous event, the executive identifies conflict situations and either provides for storage of changing state vectors or constructs an event to trigger the subdivision of one or more extended events into shorter events in order to resolve the conflict as discussed above.

The periodic evaluation of some parameterized state vector variables is performed in a code unit nicknamed MOTHER NATURE. This code unit is itself functionally divided, with modules for each class of state vector and environmental phenomena. Modules with varying degrees of sophistication may be selected at run time to allow choices of fidelity and concomittant computing costs. The time periods between regular updates are chosen to reflect the characteristics time scale for the processes involved.

Each time MOTHER_NATURE is called, it calculates an update interval and puts an appropriate EVENT in the EVENT_Q. Each MOTHER_NATURE call will be for a set of classes of STATE_VECTORS and/or environmental quantities, and every member of each of these classes is updated in a single call. Individual MOTHER_NATURE subroutines may be called by other code modules to allow accurate evaluation of critical or sensitive parameters, but the updated information is used only locally and is not stored in the REAL_WORLD.

The salient features of the engagement simulation are accomplished in the portion of the code termed ENGAGEMENT. ENGAGEMENT contains the asset simulation modules and communications and interaction physics subroutines. It is itself divided by function into BATTLE_MANAGERS, SENSORS, COMMUNICATIONS, WEAPONS, AND EVENT_PHYSICS.

These names are applicable in the very general sense: any analytical function, be it human or a microprocessor, is termed a battle manager, and any means of acquiring information is a sensor. Because of this structure, co-located but distinguishable functions of a particular installation (such as the sensor, communications, and analysis functions of an intelligent surveillance platform) will be simulated separately. All communications are treated as discrete messages contained in data structures named INFO_PACKETS.

It is in the ENGAGEMENT that the modularity of DETEC is most important, because the simulation of a variety of systems will require a wide range of asset simulation capabilities. Studies with a different emphasis will, in general, have different fidelity requirements, all of which are accomplished by selecting modules suitable to the application. The array of modules is specified by the user as part of the setup processes, and DETEC extracts the required modules from the library and links them as part of the run initialization.

The data LOGGER is the fifth main unit of DETEC. It may be called directly by the user from the MANAGER or, periodically, by the EXECUTIVE during execution. In addition to writing a variety of code data to one or several output files, the LOGGER creates user displays, restart files, and postprocessor files.

3. DESIGN APPROACH

In order to develop high-quality and maintainable software, the DETEC project is utilizing structured design and implementation techniques organized into a project development cycle. This approach is motivated by the following numbers for typical software projects: In a normal development project 15% of the time is spent on programming while 50% is spent on debugging. The average electronic data processing (EDP) organization spends 50% of its software budget on maintenance. About 80% of software maintenance cost is repairing design errors. Using the structured techniques, coupled with careful reviews reduces the number of design errors and produces high-quality and maintainable programs. The cost over the lifetime of the software is expected to be significantly less than that of programs developed using conventional techniques.

The development cycle for the DETEC project is proceeding as described below:

1. Define requirements: This step involved talking to potential users and visiting other sites that might have a competing product. No formal documentation was developed as a result of this step. It did provide essential input to the steps below.

2. Do a high-level logical design: This step resulted in a design that described the logical operation and functions of the simulation. It described how the product would work independently of the target operating system and implementation languages. The output from this design step is data-flow diagrams showing the processes required for the system and the data flow between the processes. The processes were defined using verbal descriptions and a Problem Definition Language (PDL). The standard form of the PDL is defined in the internal project guidelines document, Ref. 1. The processes and data are defined to a level of detail required for an adequate description. The method used to develop this specification is called Structured Analysis and is given in Ref. 2. The specification you are reading is the output from this step. An important part of this step is several reviews and walkthroughs to determine if the proposed product meets requirements and will perform as expected.

3. Convert to a high-level physical design: This step converts the logical design into a structured design that incorporates the details of the target operating system and implementation language. Using structured design techniques allows the design to be completed and the result evaluated. The documentation from this step is a set of structure charts that show the hierarchical structure of the program modules and their data flow. The data definitions and process definitions from the logical design are refined as necessary. Internal project reviews of this step are conducted as sections of the program design are completed. The method used to develop this specification is given in Ref. 3 and 4.

   Step 4, 5, and 6 are done as functional sections of the program are designed and implemented. For example, the detailed design for a battle- manager simulator would be done followed by coding, checkout, and putting the new function on the system. This is then repeated for other functions.

4. Prepare the detailed design: This step completes the detailed design of the internals of subroutines and other modules. This is the precise solution to the problem. The level of detail is such that these specifications can be given to a good software technician for coding, integration into the system and top down checkout. The detailed specifications are done using the PDL notation developed by the project, Ref. 1. Reviews are conducted on detailed specifications as sections of the specifcations are completed.

5. Code and check out the detailed design: This step involves converting the PDL to Cray FORTRAN, having a clean compile reviewed, installing the code into the test system, and checking it out. This is then followed by another review if major changes were made. The coding is done using the standards for Cray FORTRAN given by the project guidelines document, Ref. 1.

6. Place the program under change control: The program is placed under change control using the HIS-

TORIAN system, Ref. 5. It becomes available to the users when the next new system is brought up. The method for implementation change control has not yet been specified.

This specification was developed using the design technique called Structured Analysis, Ref. 2. The standard notation that we adopted is given in Appendix A. There are several parts to the specification. The most obvious is a data-flow diagram. Here the processes (modules) composing the system are shown along with the data that are being transferred between modules and to/from files and data sources/sinks, e.g., users. This is a model of the system from the perspective of the data flowing through the system and the transformation of the data by the identified processes. The data are defined in more detail in a data dictionary using a standard data definition. When defining a system, it is useful to start at a high level with just a few processes and data flow and then further refine the processes into additional processes with their data flows and files. This design refinement continues until, at some point, the function of some particular process is well understood and its internal workings are specified in detail using a verbal description and a short PDL. The design process is complete when all the lowest level processes have been defined by a PDL and all the data have been defined.

The notation used is that the well understood areas in the pdls are defined using all upper case letters. Less well understood areas are defined using lower case.

The bulk of the actual specification resides in sections 5-8 of this document.

5. LEVEL 0 DATA FLOW AND DESCRIPTIONS: This section contains the highest-level data-flow diagram for the simulation. It is similar to a system-level diagram. It also contains a verbal description of the high-level-processes. The data flows and files used are defined in Section 8.

6. LEVEL 1 DATA FLOW AND DESCRIPTIONS: This section contains the first expansion of all the processes from level 0. Some processes are defined using a verbal description while others can be defined using the PDL. The data flows and files are once again defined in Section 8.

7. LEVEL 2 DATA FLOW AND DESCRIPTIONS: This section contains a further expansion of some of the processes from level 1 that require a more precise description. All of the processes are defined using verbal descriptions and PDLs. The data flows are defined in Section 8.

8. DATA DEFINITIONS: This section is a data dictionary that defines all data flows and files needed by the level 0, 1, and 2 data-flow diagrams and process specifications. The data definitions are done to a level of precision needed by the rest of the specification. Some contain only a verbal description while other are defined down to the data-element level. In a very real sense, this is an essential part of the specification because it provides a functional grouping for the system data and files.

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3. E. Yourdon and L. L. Constantin, STRUTURED DESIGN, 2nd ed.(Yourdon Press., NEW YORK, NY. 1978).

4. W. P. Stevens, USING STRUCTURED DESIGN (John Wiley & Sons, INC., NEW YORK, NY. 1981).

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4. SCENARIO EXAMPLE

Thorough code walkthroughs are an essential part of the DETEC code-specification process. The purpose of walkthroughs is to verify that the code, as specified, will perform as expected. Walkthroughs are therefore required to exercise the major code elements and functions. It must also be assured that all major types of events, especially all types of potentially troublesome events, occur during the walkthrough.

The DETEC preliminary walkthrough excluded the MANAGER functions. It included most of the EXECUTIVE functions, MOTHER_NATURE, and all classes of engagement modules (BATTLE_MANAGERS, SENSORS, COMMUNICATIONS, WEAPONS, and EVENT_PHYSICS).

The walkthrough was accomplished by defining a set of initial conditions, which included one or more driving, or "trigger" events or conditions (such as launch boosters), and then following the simulation step by step through the module PDLs. For a discussion of PDL s see Section 3 . Simple but typical characteristics were defined for the individual physics and asset simulator modules. The PDLs were written to reflect these characteristics and the requirement for a variety of event types (instantaneous, extended, and conflicted). MOTHER_NATURE was designed to handle both discrete objects and grid quantities.

The following assets were chosen for a two-sided, offensive/defensive engagement:

10 ICBMs with busses (4 RVs per bus)
6 sensors (exoatmospheric)
1 AWACS platform (associated with terminal defense)
1 terminal defense system (Sprint-like)
2 space-based defensive weapons
    1 particle beam
    1 laser

2 "BOSS" battle managers
10 local battle managers
    1 on terminal defense
    1 on AWACS
    6 on sensors
    1 on laser
    1 on particle beam

The necessary MOTHER_NATURE functions for these assets are the following:

booster burn
exoatmospheric ballistic flight
endoatmospheric ballistic flight with weather effects
nuclear effects
    thermal
    blast
    prompt nuclear radiation

charged particles in the earth's magnetic field
powered endoatmospheric flight with weather effects
weather.

EVENT_PHYSICS included the following:

- laser effects on
  - boosters
  - midcourse vehicles
  - RVs
- particle beam on
  - boosters
  - midcourse vehicles
  - RVs
- nuclear effects
  - thermal on RVs
  - blast on AWACS
  - prompt radiation on Boss battle manager
- firing of
  - boosters
  - interceptors
- deployment of RVs
- STATE_VECTOR creation and destruction for all weapons.

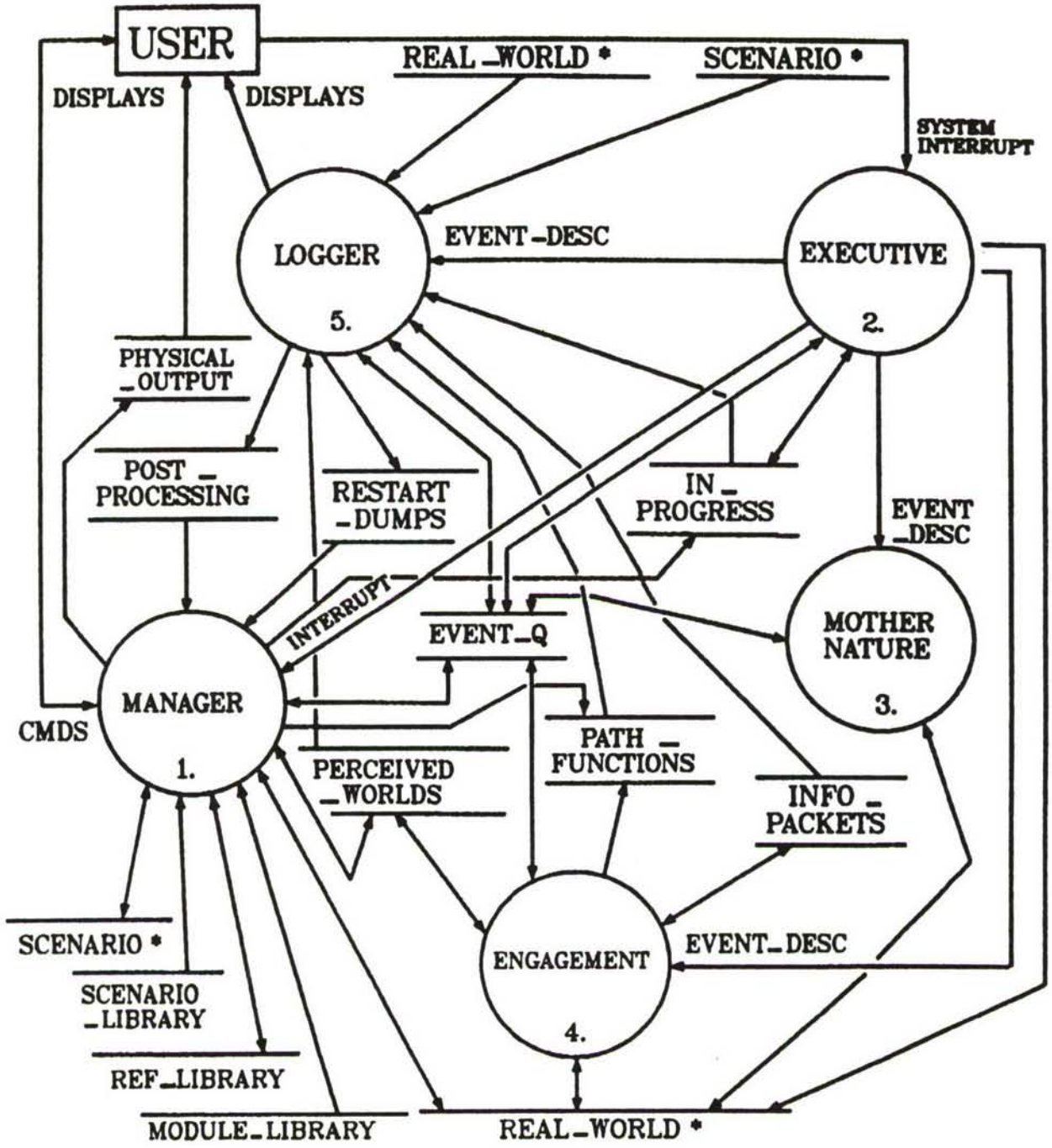
Each BATTLE_MANAGER and SENSOR had associated communication functions.

The walkthrough geometry was limited to a single plane with all orbits circular and within that plane. Correct physics was not as important to the walkthrough as representative behavior, so circular orbits of any altitude and orbital velocity were allowed.

The walkthrough was documented by a summary of each EVENT and copies of the contents of essential files at the end of the EVENT. The files documented were the following: EVENT_Q, IN_PROGRESS, REAL_WORLD, PERCEIVED_WORLDS, and PATH_FUNCTIONS. The other files shown in the DETEC level 0 data- flow diagram are associated with MANAGER or LOGGER functions, which were not treated in the walkthrough.

5. LEVEL 0 DATA FLOW AND DESCRIPTIONS

DETEC
Level 0 Data Flow



5. LEVEL 0 DATA FLOW AND DESCRIPTIONS

1.0 MANAGER

The Manager provides the user with a human-engineered interface to the simulation. The user can set up simulation initial conditions, observe and change execution, and view results after the run.

EXAMPLE: Simulate a two-combatant war with one side having offense only and the other having offense and defense.

2.0 EXECUTIVE

The Executive provides overall control of the simulation execution, uses the list of time-ordered events (EVENT_Q) to determine which functions to run next, and resolves conflicts between simulation assets.

EXAMPLE: Start a sensor module that looks at space once per second.

3.0 MOTHER NATURE

Mother Nature does the orderly evolution of currently existing real- world objects and also updates the real-world environment.

EXAMPLE: Update the position of all RVs.

4.0 ENGAGEMENT

Engagement simulates the actual assets, decisions, and interactions involved in the battle and also does the birth and death of natural objects.

EXAMPLE: An ICBM was intercepted by a laser beam; determine the extent of the damage to the ICBM.

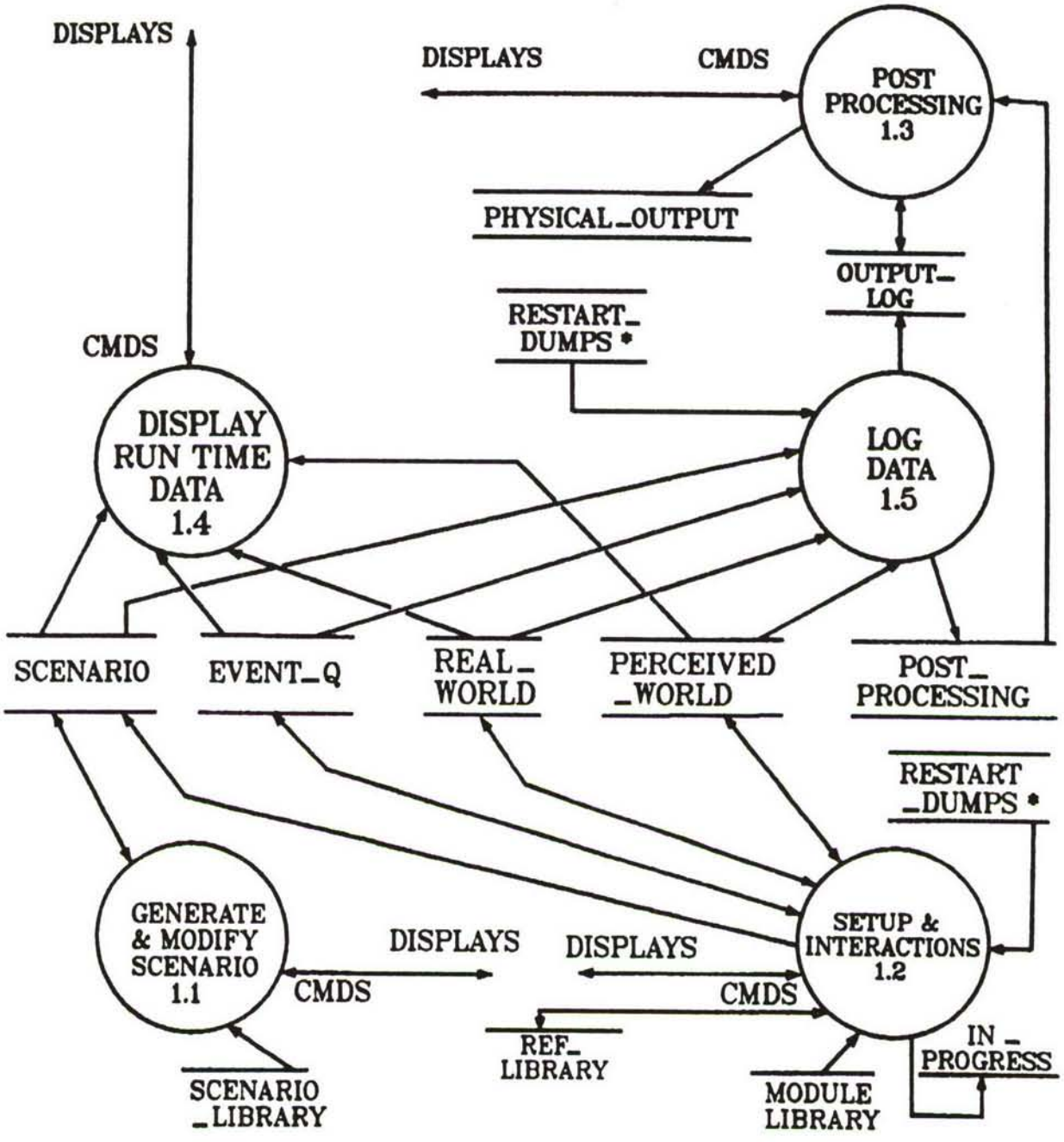
5.0 LOGGER

The Logger outputs log messages, restart dumps, and postprocessing data and updates real-time displays.

LEVEL 1 DATA FLOW AND DESCRIPTIONS

Manager
Executive
Mother Nature
Engagement
Logger

1. MANAGER
Level 1 Data Flow



1. MANAGER

1.1 GENERATE AND MODIFY SCENARIO

Based on user instructions, this process creates a new or modifies an existing scenario file. This includes defining the simulation configuration environment, battle-manager instructions, and any planned interventions.

EXAMPLE: Define the scenario for war between countries A and B. Side A has two ICBMs and side B has five anti-ICBM weapons. The side-B battle manager uses kill-at-first-chance tactic.

1.2 SETUP AND INTERVENTIONS

This process allows the user to complete the simulation setup before to execution. The user may also modify the course of an executing simulation by stopping the simulation and changing any parameters.

EXAMPLE: Select (or change) the simulation fidelity for a particular asset.

1.3 POSTPROCESSING

This process provides detailed tabular and graphical output about the simulation. It also provides post-processed figures of merit. The output is available at the user's terminal or on paper or film hardcopy.

EXAMPLE: Provide graphical output on all side-B weapon trajectories.

1.4 DISPLAY RUN TIME DATA

This process allows the user to request the display of various data so that she may observe the progress of the simulated battle.

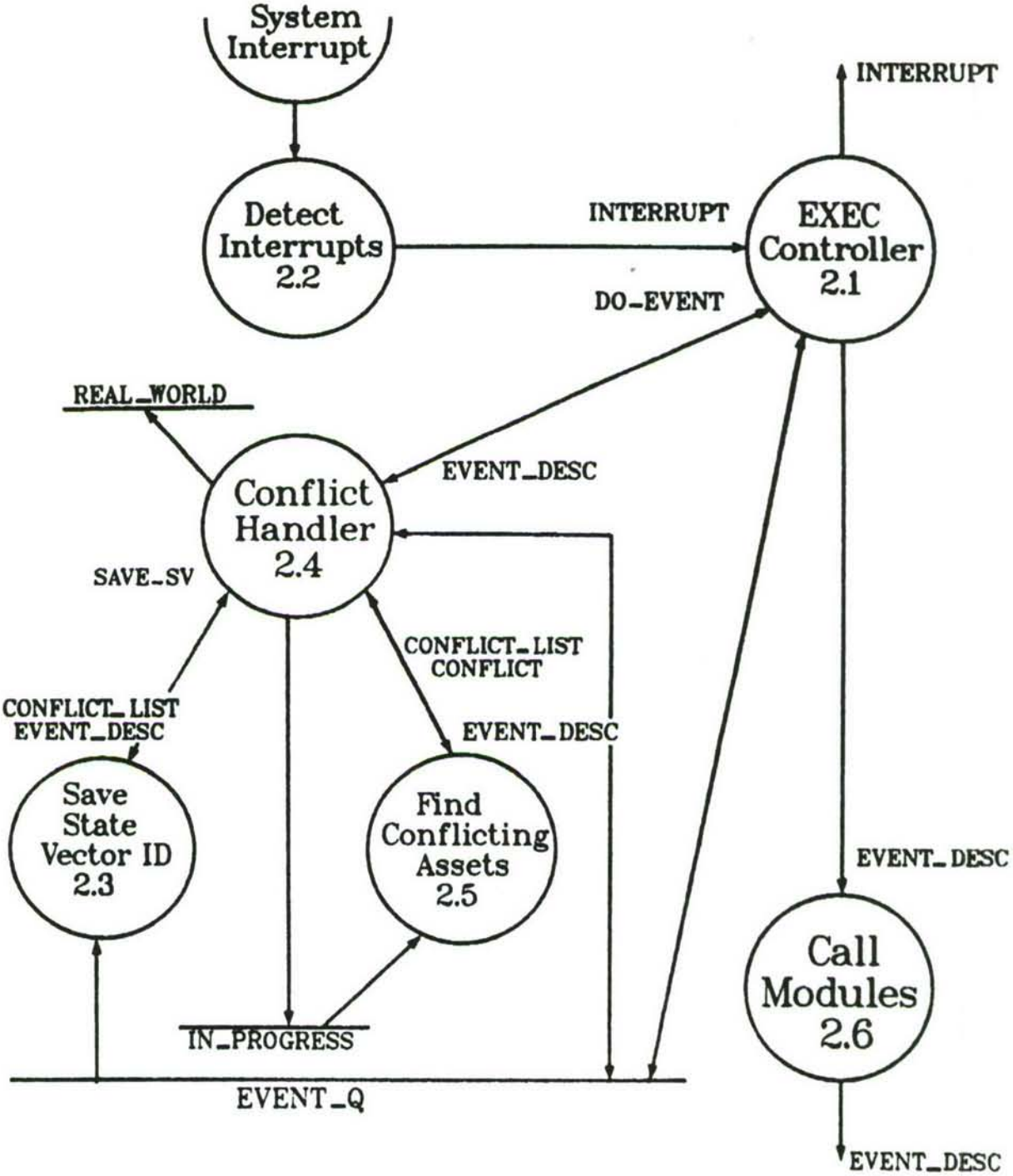
EXAMPLE: Display trajectories off all objects in space.

1.5 LOG DATA

This process allows the user to request the logging of REAL_WORLD, PERCEIVED_WORLDS, SCENARIO, EVENT_Q and other useful information. This information is written to a postprocessing file during the simulation.

```
1
2
3 ------------------------------------------------------------
4          MGR - SIMULATION CODE MANAGER
5            1.
6          ----------------------------------------
7
8            FUNCTION - THIS MODULE IS THE HIGHEST LEVEL
9              OF CONTROL FOR THE DETEC SIMULATION.  IT OBTAINS
10             INPUT FROM THE USER AND PASSES IT TO THE
11             VARIOUS MAJOR USER-INITIATED FUNCTIONS.
12
13           INPUT - NONE
14
15           OUTPUT - NONE
16
17         ------------------------------------------------------
18         MGR ()
19
20         INITIALIZE FOR THE MANAGER
21
22         DO UNTIL terminated by user
23           GET VALID USER COMMAND (CMDS)
24           CASE (cmd type)
25             WHEN (scenario)
26               GENERATE AND MODIFY SCENARIO (CMDS, DISPLAYS)  /*1.1*/
27             WHEN (setup | interventions)
28               SETUP & INTERVENTIONS (CMDS, DISPLAYS)  /*1.2*/
29             WHEN (post)
30               POSTPROCESSING (CMDS, DISPLAYS)  /*1.3*/
31             WHEN (display)
32               DISPLAY RUN TIME DATA (CMDS, DISPLAYS)  /*1.4*/
33             WHEN (log)
34               LOG DATA (CMDS, DISPLAYS)  /*1.5*/
35             WHEN (run)
36                    /*2. - RUN THE SIMULATION*/
37               CALL EXEC (INTERRUPT)
38             OTHERWISE
39               SETUP ERROR RESPONSE (CMDS, DISPLAYS)
40           END CASE
41           UPDATE DISPLAY (DISPLAYS)
42         END DO
43
44         END  /*MGR*/
```

2. EXEC
Level 1 Data Flow



Level 1

2. EXECUTIVE

The executive provides overall control of the simulation execution. It uses a list of time-ordered events to determine which functions to run next.

The executive resolves any conflicts that may exist in the simulation. A conflict is defined as the case where an asset functions while it is being damaged and/or has two or more overlapping performance requests, where the asset simulation has only minimal first-order provisions for such simulations. The provisions are that the asset simulation modules are able to simulate the asset performance using an arbirary length time step and may, in addition, be able to use modified state vectors that were saved during the conflict period. For example, a simulation conflict may require that all conflicting assets be simulated up to the current time. Another possibility is that conflicting assets be simulated using discrete time steps during the conflict interval. For the case of the saved state vectors, the saved vectors define how an asset, A, is being damaged while it is trying to damage some other asset, B. The simulation then uses the saved state vectors for A to determine the extent of the damage to asset B.

2.1 EXECUTIVE CONTROLLER

The executive controller checks for interrupts and processes EVENTs from the EVENT_Q in order by calling other EXEC modules.

2.2 DETECT INTERRUPTS

This process will detect interrupts generated by the user during execution of the simulation.

2.3 SAVE STATE VECTOR IDENTIFICATION

This module reviews the conflicts of a particular asset and determines if the related event must be stepped or if it can be in save state vector mode.

2.4 CONFLICT HANDLER

This module determines if a conflict exists for the event that is to be executed. If a conflict exists, this module determines how to resolve the conflict and puts new events into the EVENT_Q as required. The conflict resolution is done for instantaneous and extended events as described in the following paragraphs.

Instantaneous events are those physical activities that are so short that they can be simulated as occurring in an infinitesimally short time. This module performs the steps necessary to initate the execution of the modules needed to simulate an instantaneous event for some asset. If a conflict exists, this module puts events into the EVENT_Q to call the simulation modules to resolve the conflict. The asset simulations are all run to the current time, and then the asset simulation module for the instantaneous event is executed. Functions that are already in step mode do not have to be run again because they are essentially up to date.

Extended events are used to simulate those physical activities that occur over a substantial time span. This module performs the steps necessary to initiate the execution of modules to start and end the simulation of extended-time activities for an asset. If conflicts exist , this module puts events into the EVENT_Q to call the simulation modules to resolve the conflicts. Conflicts are resolved by either stepping through the conflict period using discrete time steps or by initiating the saving copies of a state vectors that change during the conflict period. The changed state vectors will be used by conflicted action modules(s) at the end of the extended event to calculate the effect of the conflict.

2.5 FIND CONFLICTING ASSETS

This module identifies events that are in conflict with the event currently being set up for execution by the executive. The identification of assets from extended-time events and the assets that they affect are stored in the IN_PROGRESS file. This process will determine if the asset identification from the current event is already in the file. If the asset is in the file, a conflict exists.

2.6 CALL MODULES

This module selects the appropriate simulation module to execute the current event.

```
 1
 2
 3 ------------------------------------------------------------------
 4          EXEC - SIMULATION EXECUTION CONTROL
 5            2.1
 6          ------------------------------------
 7
 8          FUNCTION - THIS MODULE WILL SELECT THE NEXT EVENT FROM
 9            THE EVENT QUEUE, DETERMINE IF IT IS INSTANTANEOUS
10            OR EXTENDED EVENT.  IT PUTS NEW EVENTS INTO THE EVENT_Q
11            TO RESOLVE CONFLICTS AND THEN EXECUTES THE
12            ACTUAL FUNCTION REQUIRED BY THE EVENT.
13            CONFLICTS ARE RESOLVED EITHER BY STEPPING
14            THROUGH THE CONFLICTING FUNCTIONS OR BY
15            SAVING CHANGED STATE VECTORS AND INTEGRATING OVER
16            THE CHANGES AT THE END OF THE CONFLICT.
17
18          INPUT - NONE
19
20          OUTPUT
21            INTERRUPT - THE TYPE OF INTERRUPT WHICH TERMINATED
22                        THE EXECUTIVE
23
24          ------------------------------------------------------
25          EXEC CONTROLLER (INTERRUPT)
26
27          DO UNTIL INTERRUPT = COMPLETE ! INTERVENE
28                /*2.2 -  INTERRUPT PROCESSING*/
29            CALL INTR (INTERRUPT)
30            IF INTERRUPT = NO_INTR, THEN
31              IF EVENT_Q IS EMPTY
32                INTERRUPT = COMPLETE
33              ELSE
34                GET NEXT EVENT FROM EVENT_Q (EVENT_DESC)
35                ADVANCE TIME TO TIME FROM EVENT_DESC
36
37                IF DO_NOW (from event) = TRUE
38                      /*2.6 - EXECUTE EVENT*/
39                  CALL CMODULE (EVENT_DESC)
40                  REMOVE EVENT FROM EVENT_Q (EVENT_DESC)
41                ELSE
42                      /*2.4 - RESOLVE CONFLICTS*/
43                  CALL CONHAN (EVENT_DESC, DO_EVENT)
44                  IF DO_EVENT = TRUE
45                        /*2.6 - EXECUTE EVENT*/
46                    CALL CMODULE (EVENT_DESC)
47                  END IF
```

```
48                REMOVE EVENT FROM EVENT_Q (EVENT_DESC)
49              END IF
50            END IF
51          END IF
52        END DO
53        END  /*EXEC*/
54
55
56 ------------------------------------------------------------------
57        INTR - INTERRUPT PROCESSING
58          2.2
59        -------------------------
60
61        FUNCTION - THIS MODULE DETECTS INTERRUPTS FROM THE CODE
62          USER AND RETURNS THE TYPE OF INTERRUPT
63          TO THE CALLING MODULE
64
65        INPUT - NONE
66
67        OUTPUT
68          INTERRUPT - THE TYPE OF INTERRUPT RECEIVED
69
70        ------------------------------------------------------------------
71        INTR (INTERRUPT)
72
73        IF an interrupt occurred, THEN
74          INTERRUPT = INTERVENE
75        ELSE
76          INTERRUPT = NO_INTR
77
78        END  /*INTR*/
79
80
81 ---------------------------------------------------
82        SSVID - SAVE STATE VECTOR ID
83          2.3
84        ----------------------------
85
86        FUNCTION - THIS MODULE DETERMINES IF THE SPECIFIED EVENT
87          IS A SAVE STATE VECTOR OR STEP TYPE
88
89        INPUT
90          EVENT_DESC - POINTER FOR THE EVENT IN QUESTION
91          CONFLICT_LIST - LIST OF EVENTS THAT ARE IN CONFLICT
92
93        OUTPUT
94          SAVE_SV = TRUE - EVENT IS SAVE STATE VECTOR
95                  = FALSE - EVENT IS STEP
96
```

```
97          ------------------------------------------------------
98          SSVID (EVENT_DESC, CONFLICT_LIST, SAVE_SV)
99
100         if conflict_list is empty, then
101           error
102         else
103           do for each event in conflict_list
104             if asset/event is a save_sv type
105               if event is of the form A to B
106                 A must be stepped
107                 save_sv = false
108               else
109                 A can be save_sv type
110                 save_sv = true
111               end if
112             else
113               A must be stepped
114               save_sv = false
115             end if
116           end do
117         end if
118
119         END  /*SSVID*/
120 ------------------------------------------------------------------
121         CONHAN - CONFLICT HANDLER
122           2.4
123         ----------------------
124
125         FUNCTION - THIS MODULE DETERMINES IF THE ASSETS INVOLVED
126           IN THE EVENT ARE IN CONFLICT WITH ANY EVENTS.  IF A
127           CONFLICT EXISTS, APPROPRIATE EVENTS ARE PUT INTO THE EVENT_Q
128           TO RESOLVE THE CONFLICT.
129
130         INPUT
131           EVENT_DESC - THE EVENT BEING PROCESSED
132
133         OUTPUT
134           DO_EVENT = TRUE - THE DRIVING EVENT CAN BE EXECUTED
135                    = FALSE - THE EVENT CANNOT BE EXECUTED
136
137         ------------------------------------------------------
138         CONHAN (EVENT_DESC, DO_EVENT)
139
140             /*2.5 - GET LIST OF CONFLICTING EVENTS*/
141         CALL CONFLT (EVENT_DESC, CONFLICT_LIST, CONFLICT)
142         IF CONFLICT = TRUE, THEN
143           CASE (MODE)
144             WHEN (INSTANT)
145               do_event = true
```

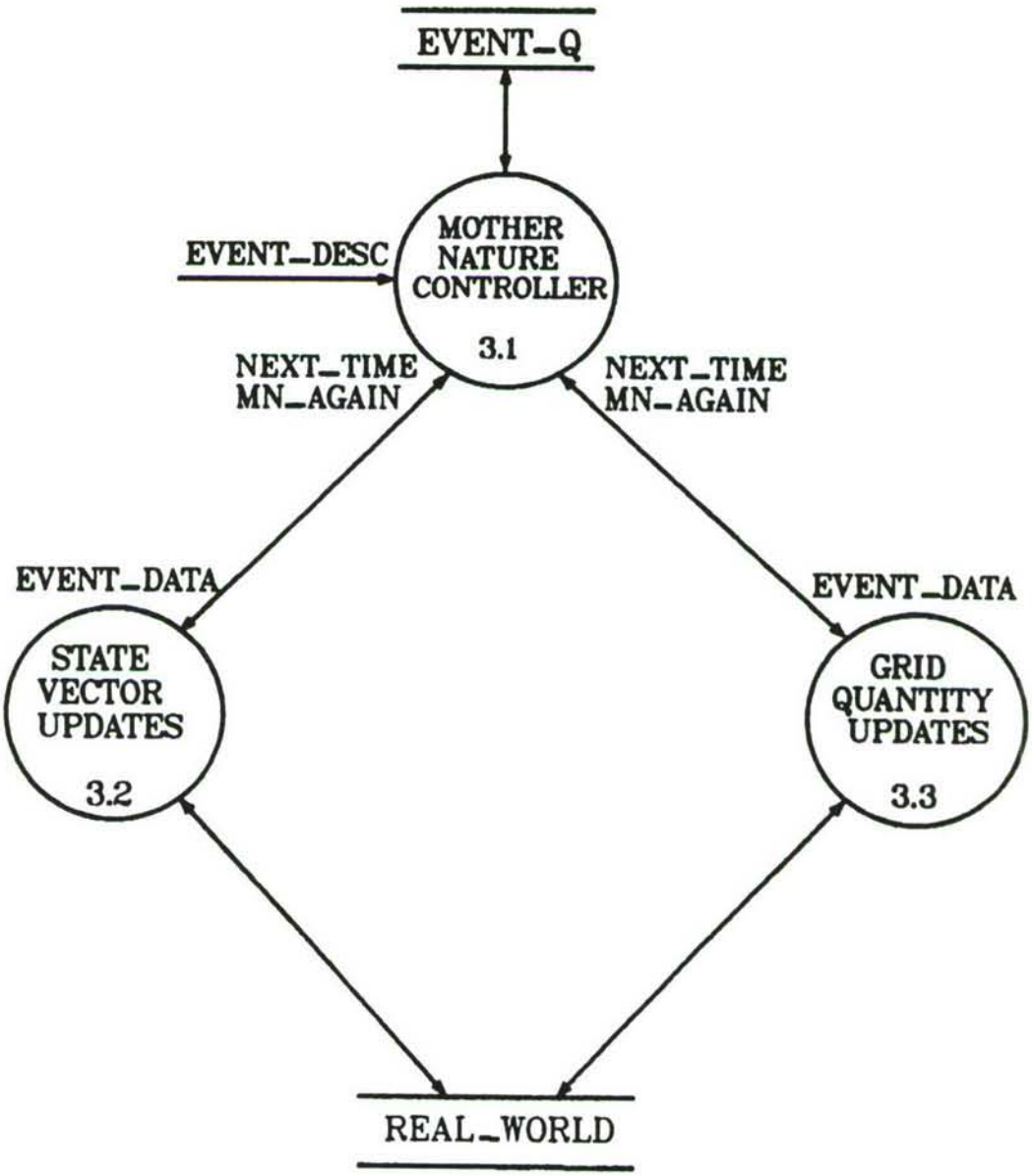
```
146               do for each event in conflict_list
147                 if event is save state vector /*2.2*/
148                   find state vector in real_world (event_desc,
149                                                    state_vector)
150                   set save_sv = true in state vector
151                 else
152                   put event into event_q to do unconflicted part
153                     of newly conflicted event at current time
154                     with mode = partial and do_now = true
155                   do_event = false
156                 end if
157               end do
158               if any conflicting event is stepped, then
159                 copy instantaneous event following the event(s)
160                   just added to event_q with do_now = true
161                   /*the original event is left in place*/
162               end if
163             WHEN (BEGINNING)
164               do for each event in conflict_list
165                 if event is save state vector /*2.3*/
166                   find state vector in real_world (event_desc,
167                                                    state_vector)
168                   set save_sv = true in state_vector
169                 else
170                   if conflicted event starts at same time as
171                     beginning event
172                     put event into event_q for conflicted event
173                       to begin step with mode = first_step
174                       and do_now = true
175                   else
176                     put event into event_q for conflicted
177                       event to do unconflicted part and then step
178                       with mode = step and do_now = true
179                   end if
180               end do
181               if any conflicting event is stepped, then
182                 copy beginning event following the event(s)
183                   just added to the event_q and set
184                   mode = first_step and do_now = true
185                   /*the original event is left in place*/
186               end if
187               add sv_id(s) to in_progress
188               DO_EVENT = FALSE
189             WHEN (ENDING)
190               do for each event in conflict_list
191                 set flag at ending event of newly unconflicted event
192                   to do last time interval (final_event_ptr)
193                 if newly unconflicted events are stepped &
194                   they no longer need to step, then
```

```
195                 find step event in event_q and remove
196               end if
197             end do
198             remove sv_id(s) from in_progress
199             DO_EVENT = TRUE
200           OTHERWISE
201             DO_EVENT = TRUE
202         END CASE
203       ELSE
204         CASE (MODE)
205           WHEN (INSTANT)
206             DO_EVENT = TRUE
207           WHEN (BEGINNING)
208             add sv_id to in_progress
209             DO_EVENT = FALSE
210           WHEN (ENDING)
211             remove sv_id from in_progress
212             DO_EVENT = TRUE
213           OTHERWISE
214             DO_EVENT = TRUE
215         END CASE
216       END IF
217
218       END  /*CONHAN*/
219
220
221 ------------------------------------------------------------------
222       CONFLT - FIND CONFLICTING EVENT
223         2.5
224       ------------------------------
225
226       FUNCTION - THIS MODULE SCANS THE LIST OF EXTENDED EVENTS
227         THAT ARE BEING SIMULATED AND DETERMINES IF ANY OF THEM
228         ARE IN CONFLICT WITH THE NEW EVENT.
229         IT RETURNS A LIST OF EVENTS THAT ARE IN CONFLICT WITH
230         THE NEW EVENT.  THE NEW EVENT IS IN THIS LIST.
231
232       INPUT
233         EVENT_DESC - THE EVENT DRIVING THIS ACTIVITY
234
235       OUTPUT
236         CONFLICT_LIST - A LIST OF ALL THE EVENTS AND ASSETS THAT
237           ARE IN CONFLICT WITH THE NEW EVENT
238         CONFLICT = TRUE - A CONFLICT HAS BEEN FOUND
239                  = FALSE - NO CONFLICT HAS BEEN FOUND
240
241       ------------------------------------------------------------
242       CONFLT (EVENT_DESC, CONFLICT_LIST, CONFLICT)
243
```

```
244          CONFLICT = FALSE
245
246          do i = 1 to number of entries in in_progress
247            if any sv_id from new event = sv_id(i) from in_progress
248              conflict = true
249              if space is available in conflict_list
250                copy in_progress entry i to next location in conflict_list
251              else
252                error
253              end if
254            end do
255
256          END  /*CONFLT*/
257
258 ------------------------------------------------------------------
259          CMODULE - CALL FUNCTIONS FOR EXEC
260            2.6
261          ---------------------------------------
262
263              FUNCTION - THIS MODULE WILL CALL THE SPECIFIED MAJOR MODULE
264                         AS DEFINED BY THE INPUT PARAMETER.
265
266              INPUT
267                EVENT_DESC - STRUCTURE WHICH POINTS TO EVENT_DATA
268                             FOR THE MODULE BEING CALLED
269
270              OUTPUT - NONE
271
272          ------------------------------------------------------
273          CMODULE (EVENT_DESC)
274
275          CASE (DESTINATION)
276            WHEN (mn id)
277              /*3. - ORDERLY EVOLUTION OF REAL WORLD OBJECTS*/
278              MOTHER NATURE (EVENT_DESC)
279            WHEN (bm id)
280              /*4.1 - DO DECISION MAKING FOR ASSETS*/
281              BATTLE MANAGERS (EVENT_DESC)
282            WHEN (sn id)
283              /*4.2 - CALCULATE SENSOR FUNCTIONING*/
284              SENSORS (EVENT_DESC)
285            WHEN (cm id)
286              /*4.3 - CALCULATE COMMUNCIATION BETWEEN ASSETS*/
287              COMMUNCIATIONS (EVENT_DESC)
288            WHEN (wp id)
289              /*4.4 - CALCULATE WEAPON FUNCTIONING*/
290              WEAPONS (EVENT_DESC)
291            WHEN (ep id)
292              /*4.5 - INTERACTIONS BETWEEN ASSETS*/
```

```
293             EVENT PHYSICS (EVENT_DESC)
294           WHEN (lg id)
295             /*5. - DUMPS, LOGS AND DISPLAYS*/
296             LOGGER (EVENT_DESC)
297           OTHERWISE
298             ERROR
299           END CASE
300         END  /*CMODULE*/
```

3. MOTHER NATURE
Level 1 Data Flow



3. MOTHER NATURE

3.1 MOTHER NATURE CONTROLLER

The Mother Nature Controller performs three functions:

1) It decodes the EVENT_DATA to determine which updates to perform.
2) It performs the control functions necessary to accomplish the updates.
3) It constructs and emplaces EVENTs in the EVENT_Q for periodic updates.

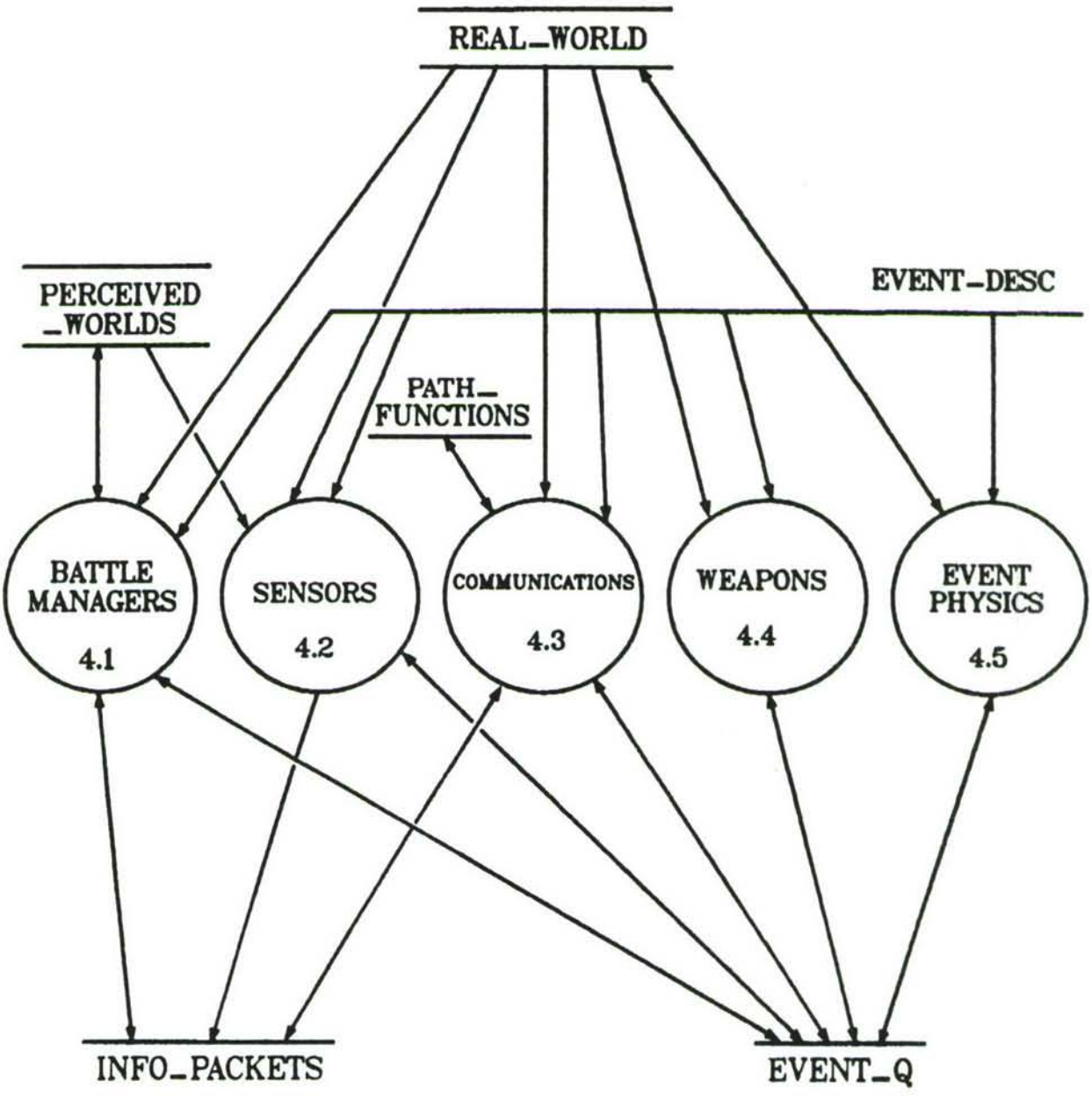
3.2 STATE VECTOR UPDATES

This is a set of modules, each of which updates a class of state vectors. The updates may include position, velocity, orientation and other geometrical type variables as well as conditions such as temperature and fuel remaining.

3.3 GRID QUANTITY UPDATES

This is a set of modules, each of which updates a grid variable, such as electromagnetic environment or the nonlocal weather. The local weather (storms) is treated on the basis of individual entities described by state vectors and updated by the State Vector Updates modules.

4. ENGAGEMENT
Level 1 Data Flow



4. ENGAGEMENT

4.1 BATTLE MANAGERS

A Battle Manager uses information sent to it by sensors, weapons, and other battle managers, along with self-generated information and information loaded during the initialization process to make decisions and send messages based on those decisions. All of the above information is stored in a battle manager's own perceived world - no other information is available for the decision process.

4.2 SENSORS

A Sensor functions as a filter on real- and perceived-world data. It can function either periodically or under explicit orders and send messages about what it has sensed to battle managers.

4.3 COMMUNICATIONS

This process simulates the communication between various assets used by the simulation. In some cases routing decisions may be made. Also, environmental effects are accounted for.

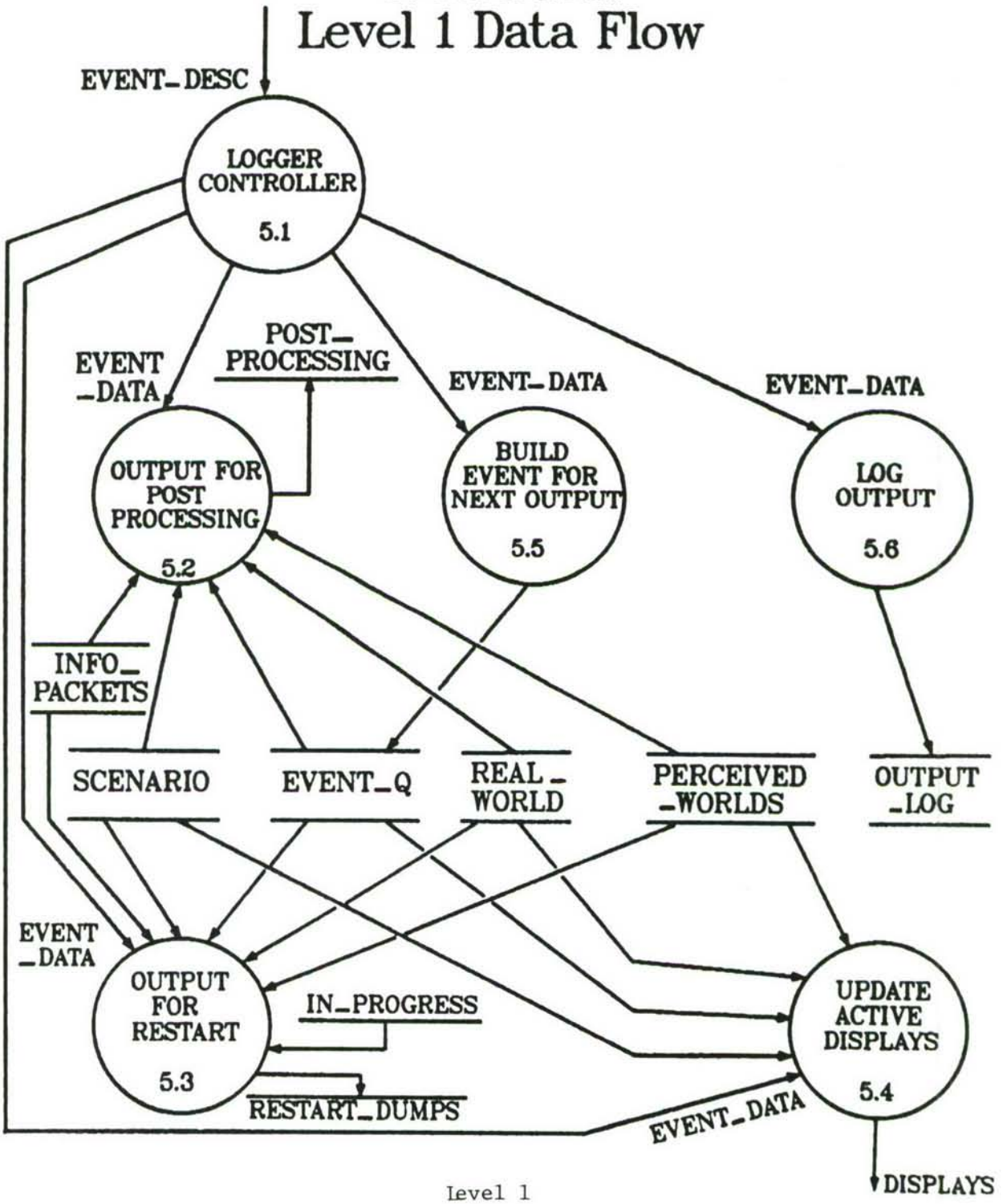
4.4 WEAPONS

A weapons module calculates the actual function of a weapon, e.g., nuclear yield for a bomb, beam duration and intensity for a laser, etc.

4.5 EVENT PHYSICS

The Event Physics module(s) calculates the interaction between a directed attack and a specific target (e.g., laser on a RV), calculates the effects of volume stresses on nearby assets (e.g., blast on a radar antenna), and performs the creation and destruction of state vectors (e.g., solar flares, spawn RV, volcanic eruption, etc.).

5. LOGGER
Level 1 Data Flow



Level 1

5. LOGGER

5.1 LOGGER CONTROLLER

This module decides which modules to run by using information from EVENT_DATA.

5.2 OUTPUT FOR POSTPROCESSING

This module dumps interesting information from the SCENARIO, EVENT_Q, REAL_WORLD, and PERCEIVED_WORLDS files. This information can then be reduced and analyzed after the simulation run by using the postprocessing functions.

5.3 OUTPUT FOR RESTART

This module makes an exact copy of all necessary files so the simulation can be restarted from this exact point at some later time if desired.

5.4 UPDATE ACTIVE DISPLAY(S)

This module will update any active displays that have been selected by the user. This allows the user to observe the progress of the simulation.

5.5 BUILD EVENT FOR NEXT OUTPUT

This module decides how long until the next output is required and generates the EVENT that will call LOGGER at the proper time. The EVENT is then added to the EVENT_Q.

5.6 LOG OUTPUT

This module logs what the LOGGER function has done during this particular call.

```
 1
 2
 3 ------------------------------------------------------------------
 4          LOGGER - DO RUN TIME OUTPUT
 5            5.1
 6          -------------------------
 7
 8          FUNCTION - THIS MODULE CALLS THE VARIOUS OUTPUT FUNCTIONS
 9            THAT CAN BE USED WHILE THE SIMULATOR IS RUNNING.
10            IT ALSO DECIDES WHEN THE NEXT OUTPUT IS NEEDED AND
11            GENERATES AN EVENT SO THAT IT WILL BE CALLED AT THE
12            APPROPRIATE TIME.
13
14          INPUT
15            EVENT_DESC - THE EVENT THAT TRIGGERED THE CALL
16
17          OUTPUT - NONE
18
19          ------------------------------------------------
20          LOGGER (EVENT_DESC)
21
22          GET EVENT FROM EVENT_Q (EVENT_DESC, EVENT_DATA)
23
24          CASE ()
25            WHEN (postprocessing)
26              OUTPUT FOR POST PROCESSING (EVENT_DATA)  /*5.2*/
27            WHEN (restart)
28              OUTPUT FOR RESTART (EVENT_DATA)  /*5.3*/
29            WHEN (display)
30              UPDATE ACTIVE DISPLAYS (EVENT_DATA)  /*5.4*/
31            OTHERWISE
32              ERROR
33          END CASE
34
35          BUILD EVENT FOR NEXT OUTPUT AND ADD
36            TO EVENT_Q (EVENT_DESC)  /*5.5*/
37          LOG OUTPUT (EVENT_DESC)  /*5.6*/
38
39          END  /*LOGGER*/
```

7. LEVEL 2 & 3 DATA FLOW AND DESCRIPTIONS

Mother Nature

Battle Manager

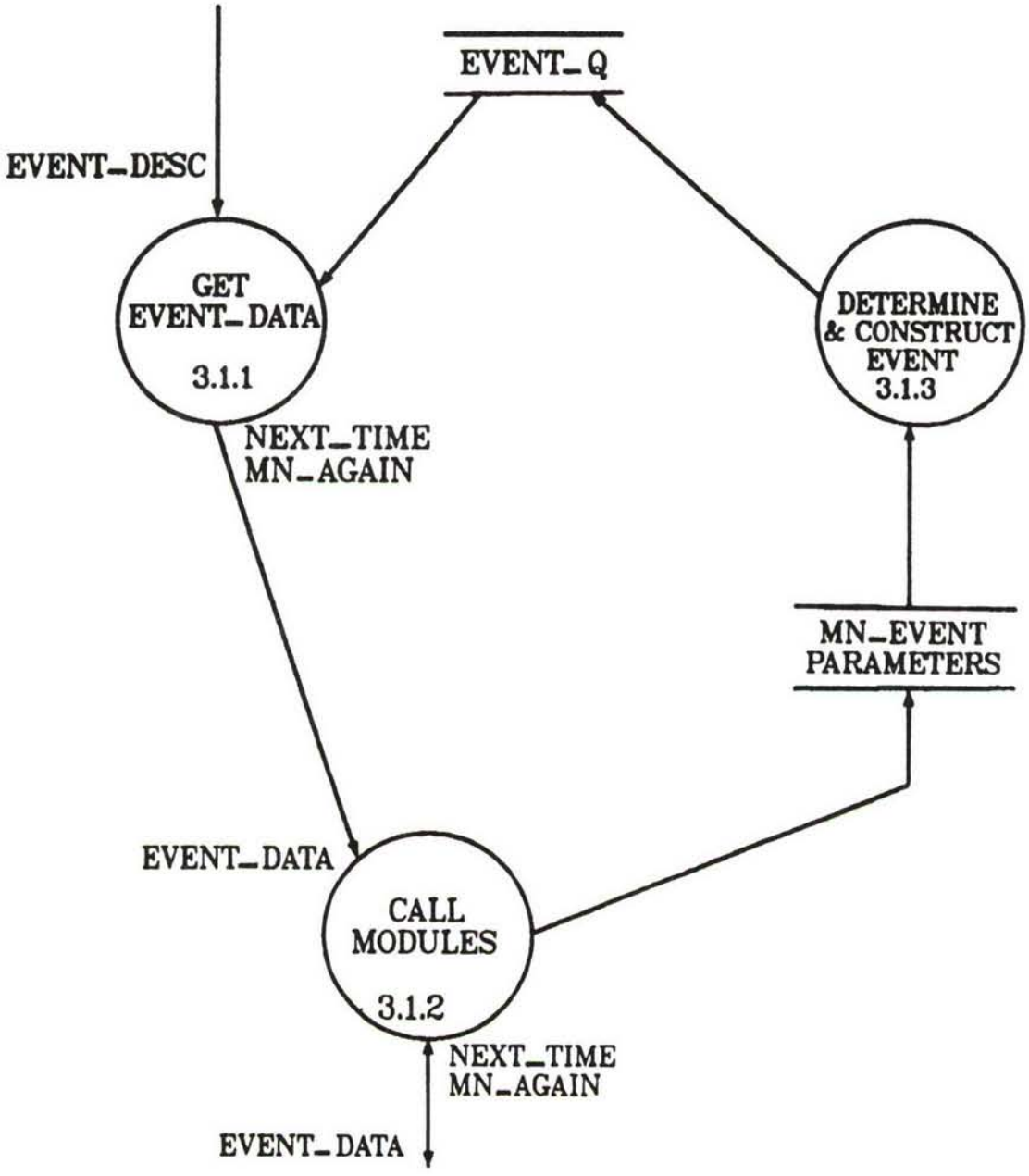
Sensors

Communications

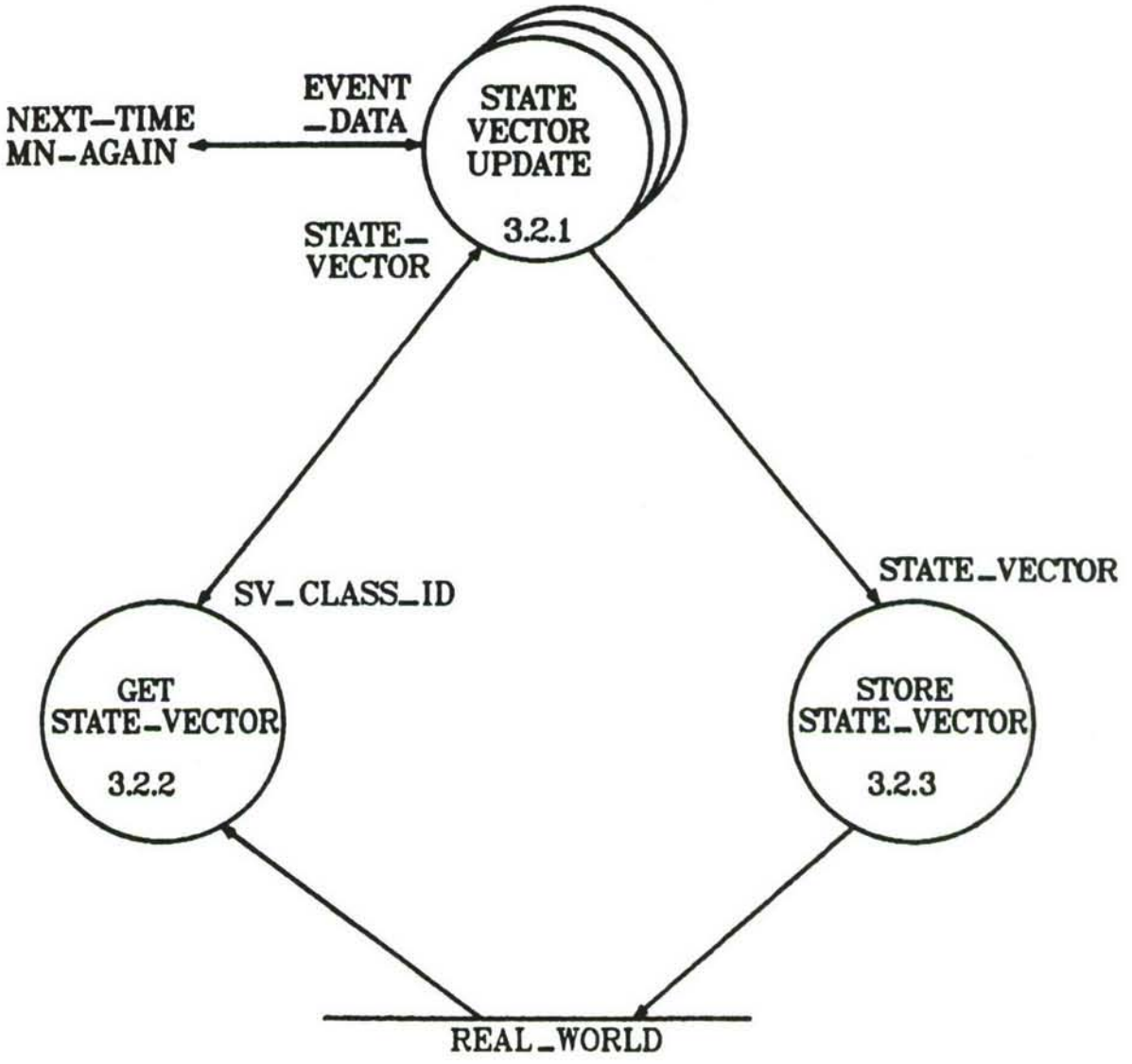
Weapons

Event Physics

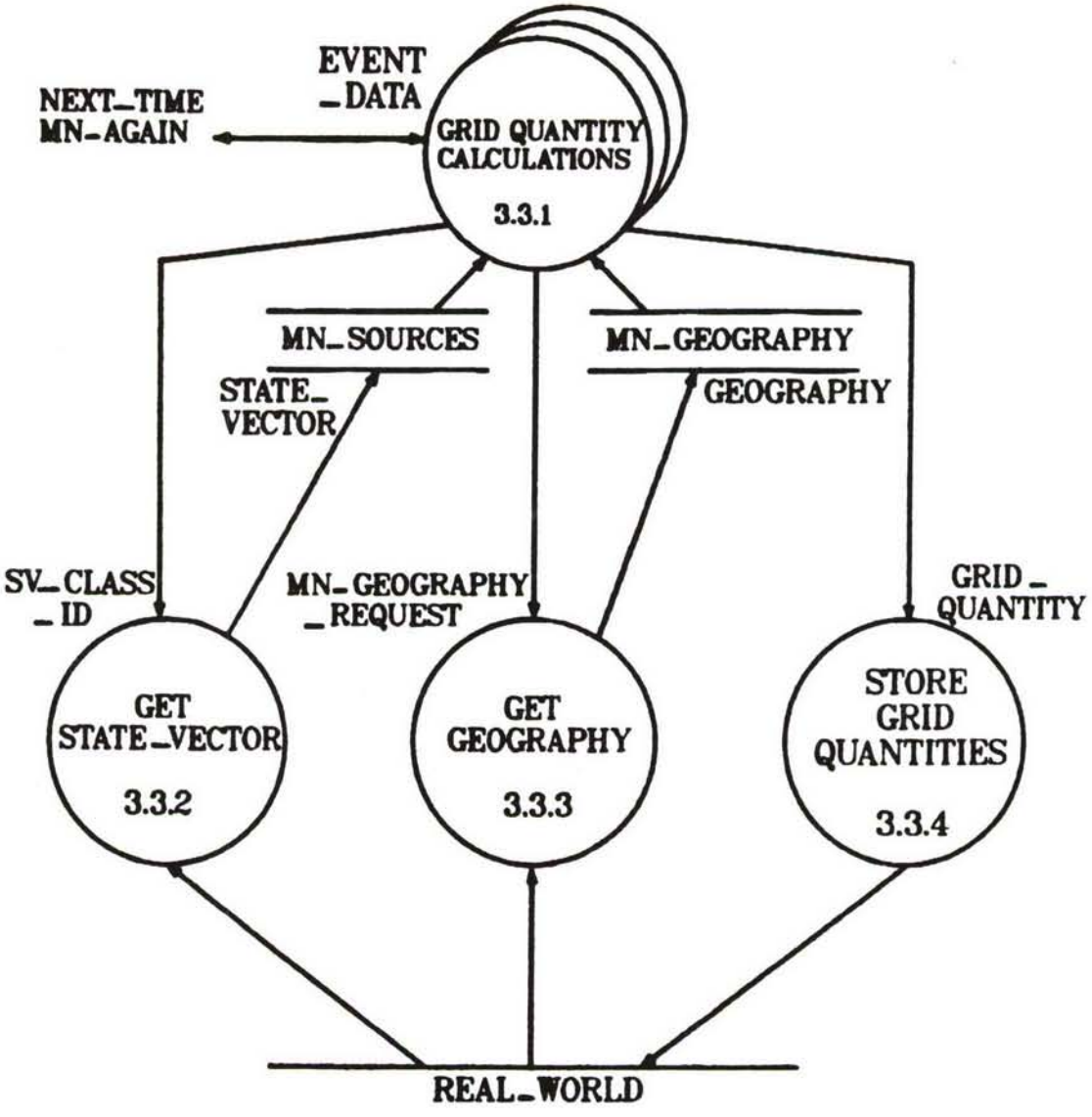
3.1 MOTHER NATURE CONTROLLER
Level 2 Data Flow



3.2 MOTHER NATURE STATE VECTOR UPDATES
Level 2 Data Flow



3.3 MOTHER NATURE GRID QUANTITY CALCULATIONS Level 2 Data Flow



Level 2 & 3

7. LEVEL 2 & 3 MOTHER NATURE

3.1 MOTHER NATURE

3.1.1 GET EVENT_DATA

This is a standard module that uses the EVENT_DESC to fetch the EVENT_DATA.

3.1.2 CALL MODULES

This module uses the EVENT_DATA to identify which classes of STATE_VECTORs and GRID_QUANTITY(ies) require updating or calculating, and calls, in turn, the correct modules to do the calculations. It may receive information from the modules on when they should be recalculated, and it writes this information in the MN_EVENT_PARAMETERS file.

3.1.3 DETERMINE AND CONSTRUCT EVENT

This module analyzes the data in the MN_EVENT_PARAMETERS file to determine when and how Mother_Nature should be called again. It then constructs the necessary EVENTs and puts them in the EVENT_Q.

3.2.1 CLASS n STATE_VECTOR UPDATE MODULE

This is a set of update modules, one for each class of STATE_VECTORs. Each uses the existing parametric description within the STATE_VECTOR to calculate new values of a set of variables for the current time.

3.2.2 GET STATE VECTORS

This module gets from the REAL_WORLD all STATE_VECTORs with the SV_CLASS_ID.

3.2.3 STORE STATE_VECTORs

This module stores the updated STATE_VECTORs in the appropriate places in the REAL_WORLD.

3.3.1 GRID QUANTITY CALCULATIONS

This represents a set of modules, each of which does the calculations of a GRID_QUANTITY (e.g. electromagnetic environment or nonlocal weather) for a specific time, and for all grid locations. It uses the source STATE_VECTORs and GEOGRAPHY put in the MN_SOURCE and MN_GEOGRAPHY files by Get State Vectors and Store State Vectors and ships the calculated quantities to Store Grid Quantities for storage.

3.3.2 GET STATE_VECTORs

This module gets from the REAL_WORLD all STATE_VECTORs with a specific SV_CLASS_ID and writes them to the MN_SOURCES and MN_GEOGRAPHY files.

3.3.3 GEOGRAPHY

This module gets from the REAL_WORLD whatever GEOGRAPHY information has been requested by Grid Quantity Calculations using the parameter MN_GEOGRAPHY_REQUEST and writes it in the MN_SOURCES and MN_GEOGRAPHY files.

3.3.4 STORE GRID QUANTITIES

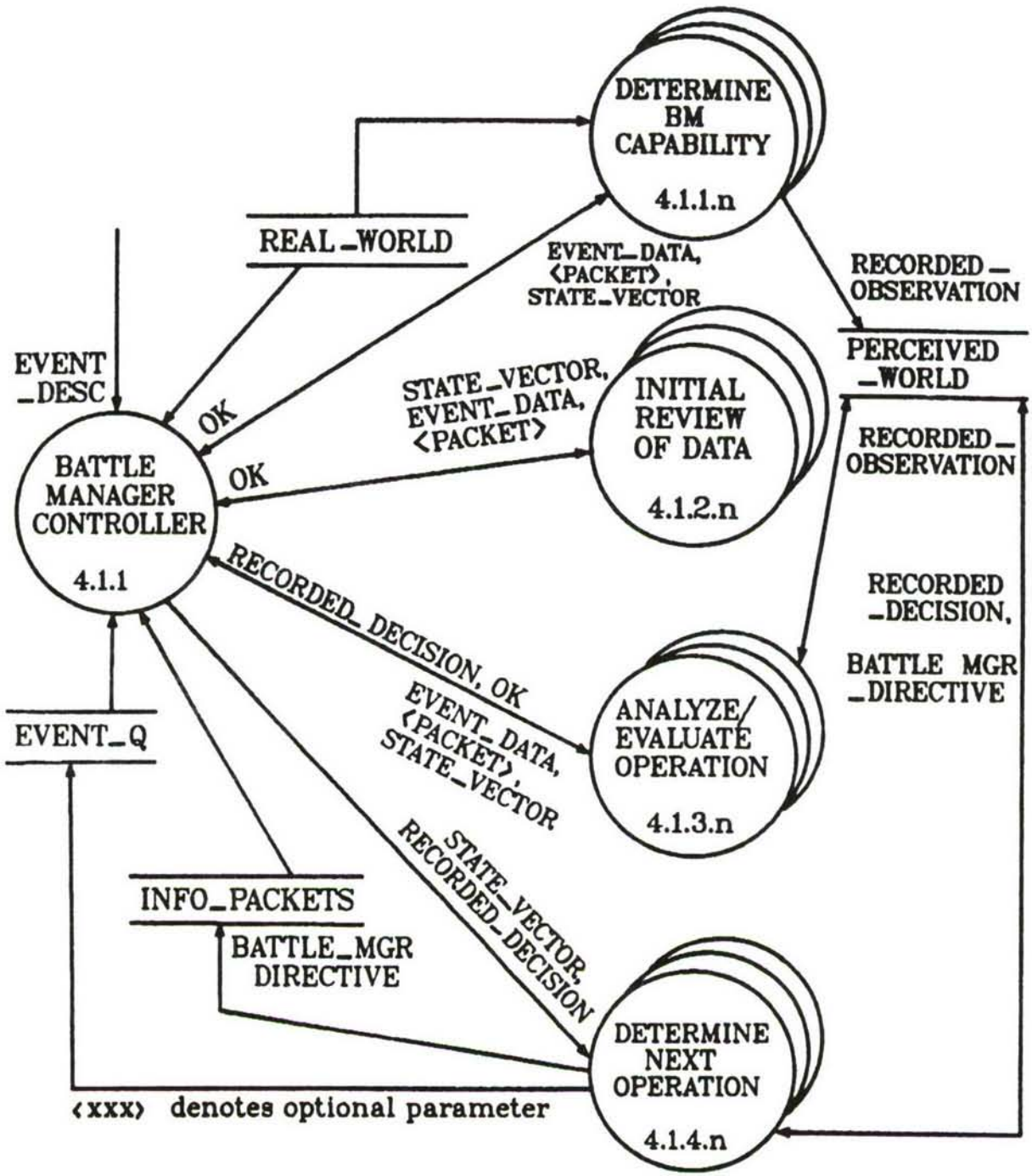
This module accepts GRID_QUANTITY and writes it to the appropriate place in the REAL_WORLD file.

```
1
2
3  ------------------------------------------------------------
4          MN - MOTHER NATURE
5            3.1
6          -----------------
7
8          FUNCTION - THIS MODULE GETS THE EVENT FOR THE MOTHER NATURE
9            MODULES, CALLS THE VARIOUS MODULES AND CONSTRUCTS THE
10           EVENTS FOR THOSE MODULES REQUIRING CALLS TO DO PERIODIC
11           OR ADDITIONAL MOTHER NATURE CALCULATIONS.
12
13         INPUT
14           EVENT_DESC - THE EVENT THAT TRIGGERED THE CALL
15
16         OUTPUT
17           NONE
18
19         ------------------------------------------------------------
20         MN (EVENT_DESC)
21
22         GET EVENT FROM EVENT_Q (EVENT_DESC, EVENT_DATA)  /*3.1.1*/
23         DETERMINE FROM EVENT_DATA THE MODULES TO BE CALLED
24         DO FOR EACH MODULE TO BE CALLED
25           CALL module (TIME, NEXT_TIME, MN_AGAIN)  /*3.1.2*/
26           IF MN_AGAIN = TRUE
27             WRITE NEXT_TIME & SV_ID TO MN_EVENT_PARAMETERS
28           END IF
29         END DO
30         ANALYZE ENTRIES IN MN_EVENT_PARAMETERS
31           DETERMINE AND CONSTRUCT EVENTS  /*3.1.3*/
32         END DO
33         END  /*MN*/
34
35
36 ------------------------------------------------------------------
37         MNSVUP - MOTHER NATURE STATE VECTOR UPDATE
38           3.2
39         ---------------------------------------
40
41         FUNCTION - THIS IS A SERIES OF MODULES EACH OF WHICH UPDATES
42           A CLASS OF STATE VECTORS SUCH AS POSITION, VELOCITY, AND
43           FUEL REMAINING.
44
45         INPUT
46           EVENT_DATA - THE EVENT WHICH TRIGGERED THE MODULE CALL
47
```

```
48          OUTPUT
49            NEXT_TIME - THE TIME WHEN THIS MODULE IS TO BE CALLED AGAIN
50            MN_AGAIN = TRUE - CALL THIS MODULE MN_AGAIN
51                     = FALSE - DO NOT CALL THIS MODULE MN_AGAIN
52
53          ------------------------------------------------------------
54          MNSVUP (EVENT_DATA, NEXT_TIME, MN_AGAIN)
55
56          GET ALL STATE_VECTORS FROM REAL_WORLD FOR SV_CLASS_ID  /*3.2.2*/
57          DO FOR EACH RETRIEVED STATE_VECTOR
58            UPDATE THE STATE_VECTOR (EVENT_DATA, STATE_VECTOR)  /*3.2.1*/
59          END DO
60          STORE ALL THE MODIFIED STATE_VECTORS INTO REAL WORLD  /*3.2.3*/
61          if module needs to run again
62            compute NEXT_TIME
63            MN_AGAIN = TRUE
64          else
65            MN_AGAIN = FALSE
66          end if
67          END  /*MNSVUP*/
68
69
70 ------------------------------------------------------------
71          MNGRID - MOTHER NATURE GRID QUANTITY CALCULATIONS
72            3.3
73          ------------------------------------------------
74
75          FUNCTION - THIS IS A SET OF MODULES EACH OF WHICH
76            UPDATES A GRID VARIABLE SUCH AS ELECTROMAGNET
77            ENVIRONMENT OR THE NON LOCAL WEATHER.
78
79          INPUT
80            EVENT_DATA - THE EVENT WHICH TRIGGERED THE MODULE CALL
81
82          OUTPUT
83            NEXT_TIME - THE TIME WHEN THIS MODULE IS TO BE CALLED AGAIN
84            MN_AGAIN = TRUE - CALL THIS MODULE MN_AGAIN
85                     = FALSE - DO NOT CALL THIS MODULE MN_AGAIN
86
87          ------------------------------------------------------------
88          MNGRID (EVENT_DATA, NEXT_TIME, MN_AGAIN)
89
90          GET ALL STATE VECTORS FROM REAL_WORLD FOR SV_CLASS_ID  /*3.3.2*/
91          WRITE RETRIEVED STATE_VECTORS TO MN_SOURCES
92          GET GEOGRAPHY FOR MN_GEOGRAPHY_REQUEST FROM REAL_WORLD /*3.3.3*/
93          WRITE RETRIEVED GEOGRAPHY TO MN_GEOGRAPHY
94          DO FOR EACH_GRID QUANTITY
95          CALL module TO CALCULATE VARIABLE GRID QUANTITY /*3.3.1*/
96            STORE GRID_QUANTITY INTO REAL_WORLD  /*3.3.4*/
```

```
 97          END DO
 98          if module needs to be run again
 99            compute NEXT_TIME
100            MN_AGAIN = TRUE
101          else
102            MN_AGAIN = FALSE
103          end if
104
105          END  /*MNGRID*/
```

4.1 BATTLE MANAGER
Level 2 Data Flow



LEVEL 2 & 3 BATTLE MANAGERS

4.1 BATTLE MANAGER

4.1.1 BATTLE MANAGER CONTROLLER

There is a battle manager for every asset that is required to make any decisions and/or report results. The controller process gets data for the battle manager processes and determines which processes to call.

4.1.1.n DETERMINE BATTLE MANAGER CAPABILITY

This process determines what is required of the battle manager in the execution of this event. Based on the battle manager's state vector and perceived world information, this process determines if the battle manager is capable of performing its function.

4.1.2.n INITIAL REVIEW OF PACKET

This process gets all data that may be received at this time and may perform a cursory first review of the data, including consistency and applicability checks.

4.1.3.n ANALYZE/EVALUATE OPERATIONS

This process examines the battle manager's perceived world and other data and performs analyses and evaluations of the current and/or projected situation. This can be triggered by the reception of unexpected information, the reception of information for an existing operation, an interruption for an existing operation, or a self-triggered evaluation. At this time the battle manager may record its observations in its perceived world.

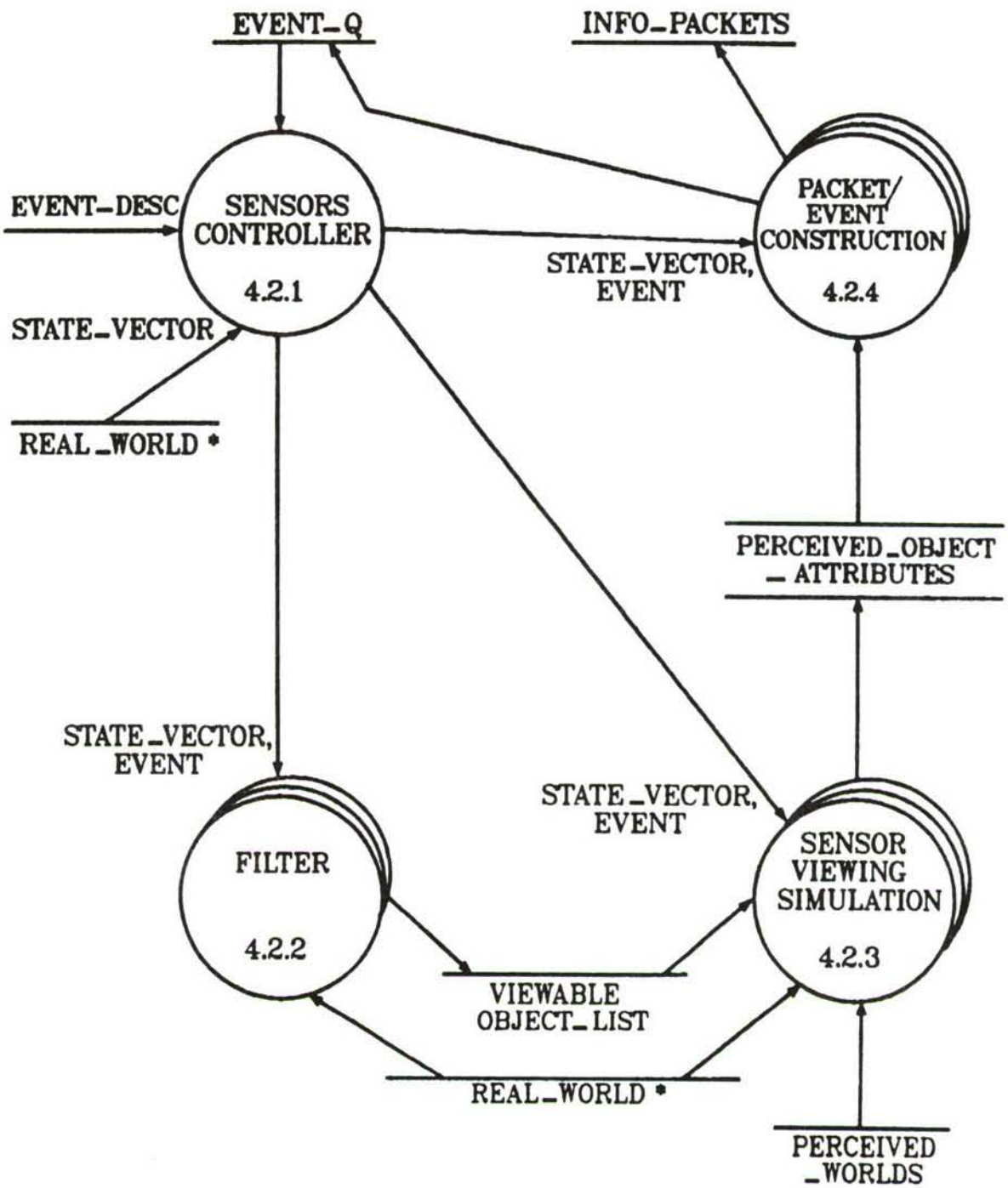
4.1.4.n DETERMINE NEXT OPERATION

Based on the above analysis, the battle manager may decide to start a new operation, continue an existing operation, or terminate an operation. This process generates the EVENTs and PACKETs required to do this and may record the battle manager's decisions in its perceived world.

```
 1
 2
 3
 4 ------------------------------------------------------------------
 5          bm - battle manager for generic function
 6            4.1.1
 7          ----------------------------------------
 8
 9          function - This module is supposed to give a rough
10            idea of how a real battle manager will use the data
11            and the type of control required.
12
13          input
14            event_desc - pointer to the event driving the battle manager
15
16          output - none
17
18          ----------------------------------------
19          bm (event_desc)
20
21          get event from event_q (event_desc, event_data)
22          get battle manager state_vector from real_world
23          extract damage from bm state_vector
24          if damage = dead, then
25            log receipt of event for dead asset
26          else  /*asset may be functioning*/
27            if event_data indicates a packet accompanies the event, then
28              get packet from info_packets (event_data, packet)
29            end if
30            extract specific module number from event_data
31            case (mode)
32              when (first_step)
33                if time of next step < time of final event
34                  build event for first step (event_data)
35                  put into event_q (event_data)
36                end if
37              when (partial | step | last_step | instant)
38                if module is used, then
39                  determine battle mgr capability (event_data,
40                                          <packet, state_vector, ok)  /*4.1.1.n*/
41                      /* <xxx> indicates an optional parameter*/
42                end if
43                if ok = true  /*if bm has capability to continue*/
44                  & module is used, then
45                  initial review of data (event_data,<packet>, state_vector, ok)
46                                          /*4.1.2.n*/
47                end if
```

```
48              if ok = true  /*if data satisfied the initial review*/
49                & module is used, then
50                analyze/evaluate operations (event_data, <packet>,
51                      state_vector, recorded_decision, ok)  /*4.1.3.n*/
52              end if
53              if ok = true  /*if bm needs to continue this operation*/
54                & module is used, then
55                determine next operation (state_vector,
56                                          recorded_decision)  /*4.1.4.n*/
57                if (mode = step & calculation will continue &
58                    time of next step < time of final_event)
59                  build event for next step (event_data)
60                  put into event_q (event_data)
61                end if
62              else
63                error
64              end if
65            otherwise
66                error
67          end case
68        end if
69
70        end  /*bm*/
```

4.2 SENSORS
Level 2 Data Flow



4.2 SENSORS

4.2.1 SENSORS CONTROLLER

This module does the following: gets the EVENT_DATA appropriate to the EVENT_DESC, and analyzes the EVENT_DATA to determine the SENSOR_OPERATING_PARAMETERS and a specific sensor ID. It performs the control functions to call the other modules within Sensors.

4.2.2 FILTER

This is one of a set of modules that uses the SENSOR_OPERATING_PARAMETERS and object STATE_VECTORs to determine which objects are viewable by a particular sensor. The viewable STATE_VECTORs are written to the VIEWABLE_OBJECTS_LIST.

4.2.3 SENSOR VIEWING SIMULATION

This is one of a set of modules, each of which simulates the functioning of a specific sensor type. It uses condition parameters from the appropriate installation STATE_VECTOR along with ENVIRONMENT and possibly GEOGRAPHY to determine the appropriate perception of each object in the viewable objects list.

4.2.4 EVENT / PACKET CONSTRUCTION

This is a set of modules, one for each sensor type, which does the following:

1) performs routine analysis (analysis not requiring a Battle Manager) of the perceived data, e.g., sorts the objects according to whether on not they match a predetermined signature,
2) constructs the PACKET(s) to be transmitted to Battle Manager(s),
3) constructs an EVENT for the transmission to be accomplished, and
4) writes the PACKET and EVENT to the appropriate files.

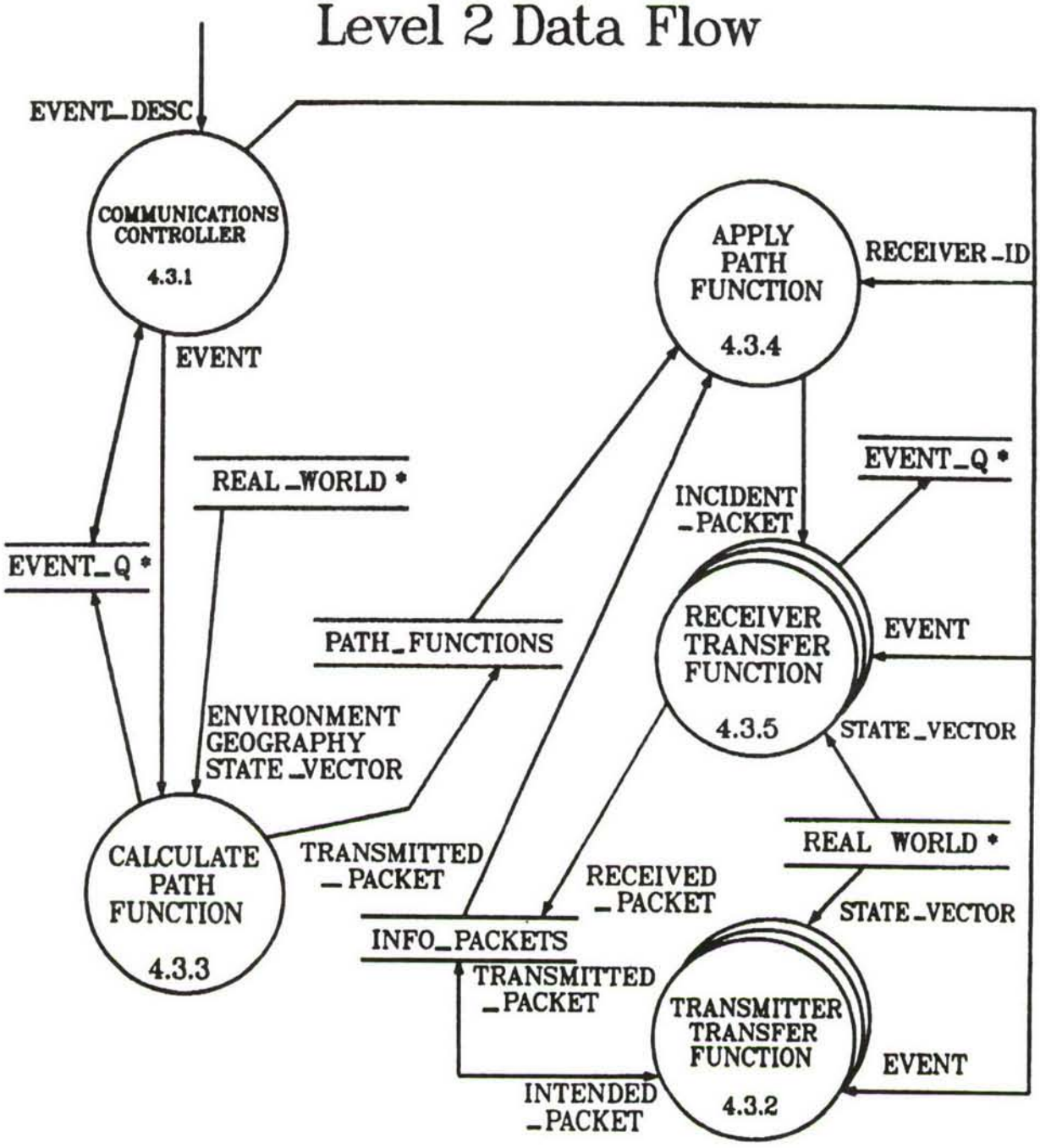
```
 1
 2
 3 ------------------------------------------------------------------
 4          SENSOR - SIMULATE SENSORS
 5            4.2.1
 6          -------------------------
 7
 8          FUNCTION - A SENSOR FUNCTIONS AS A FILTER ON REAL-
 9            AND PERCEIVED-WORLD DATA.  SENSORS MAY OPERATE PERIODICALLY,
10            CONTINUOUSLY, OR UPON COMMAND.
11
12          INPUT
13            EVENT_DESC - THE EVENT DRIVING THIS ACTIVITY
14
15          OUTPUT
16            NONE
17
18          ------------------------------------------------------
19          SENSORS (EVENT_DESC)
20
21          get event from event_q (event_desc, event_data)
22          get sensor state_vector from real_world
23          extract damage from sensor state_vector
24          if damage = dead, then
25            log receipt of event for dead asset
26          else  /*asset may be functioning*/
27            extract specific module number from event_data
28            case (mode)
29              when (first_step)
30                if time of next step < time of final event, then
31                  build event for first step
32                  put into event_q (event_data)
33                end if
34              when (partial | step | last step | instant)
35
36                     /*4.2.2 - determine if object is viewable*/
37                call filter (state_vector, event)
38                     /*4.2.3 - do sensor viewing simulation*/
39                call svs (state_vector, event)
40                     /*4.2.4 - construct packet and event*/
41                call pec (state_vector, event)
42                if mode = step & calculation is to continue &
43                   time of next step < time of final event
44                  build event for next step (event_data)
45                  put into event_q (event_data)
46                end if
47
```

```
48              otherwise
49                error
50            end case
51          end if
52
53          END  /*SENSOR*/
54
55
56 ------------------------------------------------------------------
57          FILTER - DETERMINE IF OBJECT IS VIEWABLE
58            4.2.2
59          ----------------------------------------
60
61          FUNCTION - THIS MODULE USES THE SENSOR OPERATING PARAMETERS
62            AND OBJECT STATE VECTORS TO DETERMINE WHICH OBJECTS
63            ARE VIEWABLE BY THE SENSOR. THE VIEWABLE OBJECTS'
64            STATE_VECTORS ARE WRITTEN TO THE VIEWABLE_OBJECT_LIST FILE.
65
66          INPUT
67            STATE_VECTOR - SENSOR STATE_VECTOR
68            EVENT - THE EVENT DRIVING THIS ACTIVITY
69
70          OUTPUT
71            NONE
72
73          ------------------------------------------------------
74          FILTER (STATE_VECTOR, EVENT)
75
76          get sensor_operating_parameters from event_data
77          find viewable sectors for sensor_operating_parameters
78          do for each viewable sector
79            do for each object in sector for class of interest
80              get state_vector for object from real_world
81              calculate if viewable
82              if viewable, then
83                write object's state_vector to viewable_object_list
84              end if
85            end do
86          end do
87          do background for filter
88          write background sources to viewable_object_list
89
90          END  /*FILTER*/
91
92
93 ------------------------------------------------------------------
94          SVS - SENSOR VIEWING SIMULATION
95            4.2.3
96          ----------------------------
```

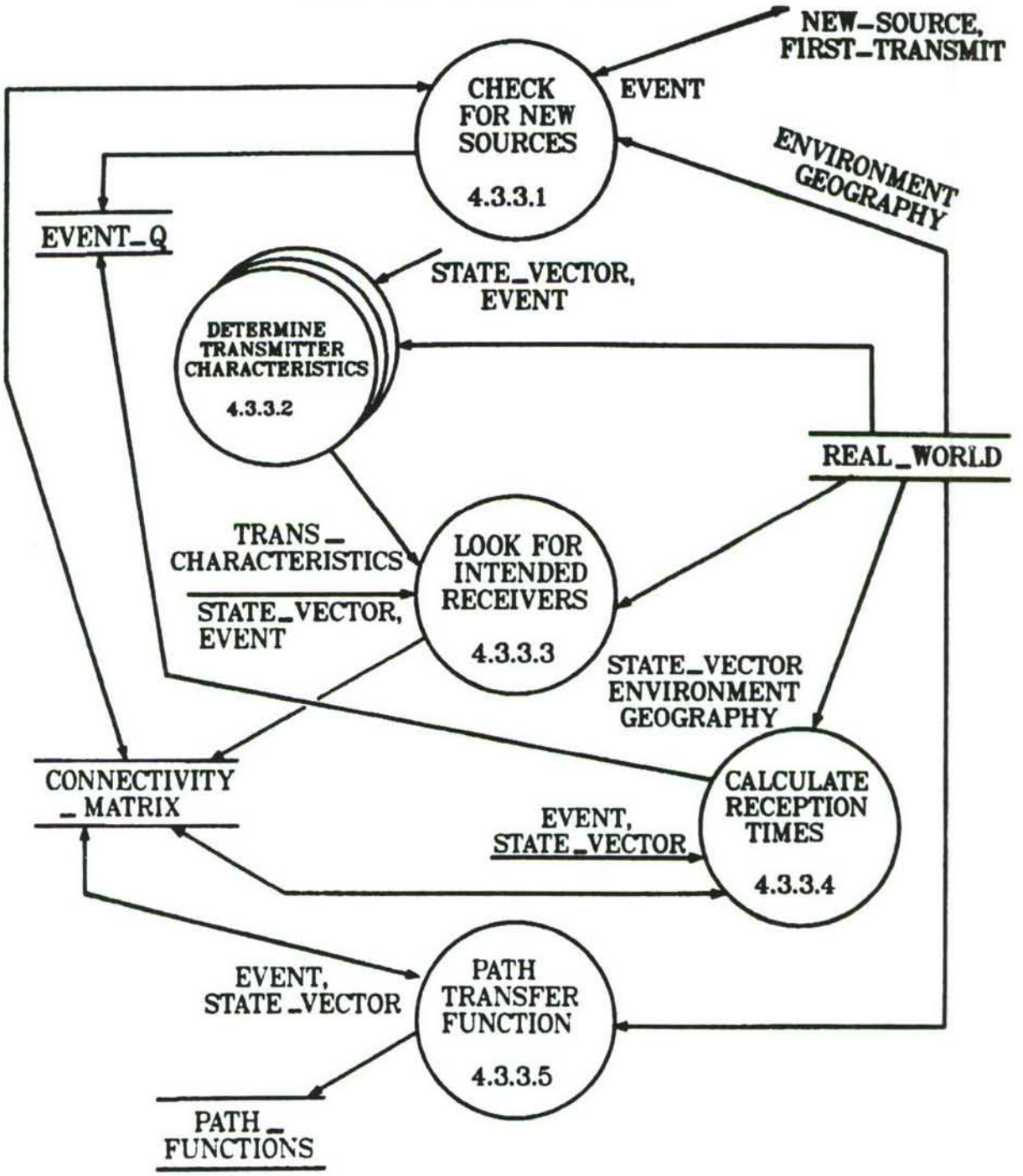
```
 97
 98          FUNCTION - THIS MODULE USES THE SENSOR STATE_ VECTOR ALONG
 99            WITH ENVIRONMENT AND PERHAPS GEOGRAPHY TO DETERMINE
100            THE APPROPRIATE PERCEPTION OF AN OBJECT.
101
102          INPUT
103            STATE_VECTOR - SENSOR STATE_VECTOR
104            EVENT - THE EVENT FOR THIS ACTIVITY
105
106          OUTPUT
107            NONE
108
109          ------------------------------------------------------
110          SVS (STATE_VECTOR, EVENT)
111
112          get sensor_operating_parameters from event_data
113          if other parameters are needed
114            get additional sensor_operating parameters from state_vector
115          end if
116          do for each object in viewable_object_list
117            do viewing simulation to produce perceived_attributes
118            write perceived_attributes to perceived_object_attributes
119          end do
120          do sensor background simulation
121          write background to perceived_object_attributes
122
123          END  /*SVS*/
124
125
126 ------------------------------------------------------------------
127          PEC - CONSTRUCT PACKET AND EVENT
128            4.2.4
129          ----------------------------------
130
131          FUNCTION
132            THIS MODULE CONSTRUCTS ANY PACKET APPROPRIATE FOR THIS
133            EVENT, AND CONSTRUCTS AND STORES AN EVENT TO SEND THE PACKET.
134
135          INPUT
136            STATE_VECTOR - THE STATE_VECTOR OF A PARTICULAR SENSOR
137            EVENT - THE EVENT DRIVING THIS ACTIVITY
138
139          OUTPUT
140            NONE
141
142          ------------------------------------------------------------
143          PEC (STATE_VECTOR, EVENT)
144
145          determine if a packet is to be sent
```

```
146         if a packet is to be sent
147           construct the packet
148           store the packet in INFO_PACKETS
149           construct the EVENT to send the PACKET
150           put the EVENT in the EVENT_Q
151         end if
152         if sensor needs to run again
153           build event to restart sensor (event_ data)
154           put into event_q (event_data)
155         end if
156
157         END  /*PEC*/
```

4.3 COMMUNICATIONS
Level 2 Data Flow



4.3.3 COMMUNICATIONS CALCULATE PATH FUNCTIONS Level 3 Data Flow



Level 2 & 3

4.3.1 COMMUNICATIONS CONTROLLER

This process does the overall control of the communciation function.

4.3.2 TRANSMITTER TRANSFER FUNCTION

This is a series of modules, each of which represents a type of transmitter. Each module uses the STATE_VECTOR, including damage parameters for a particular transmitter installation, to transform the INTENDED_PACKET into the TRANSMITTED_PACKET. The TRANSMITTED_PACKET may include parametric transmission characteristics such as frequency, antenna pattern type, power level, signal-to-noise ratio, and transmitter location. At some fidelity levels, the transmitter module functions may depend on ENVIRONMENT data from REAL_WORLD.

4.3.3 CALCULATE PATH FUNCTION

This module computes the transform for the communciation path. For multiple paths to the same receiver, a composite transform is completed.

4.3.4 APPLY PATH FUNCTION

The module does the actual convolution of the path transfer function with a TRANSMITTED_PACKET to give an INCIDENT_PACKET.

4.3.5 RECEIVER TRANSFER FUNCTION

This is a series of modules, each representating a type of receiver. Each module uses the STATE_VECTOR, including damage parameters for a particular receiver installation, to transform the INCIDENT_PACKET into the RECEIVED_PACKET. At some fidelity levels, the receiver module function may depend on ENVIRONMENT data from REAL_WORLD.

4.3.3.1 CHECK FOR NEW SOURCES

This module determines if some new sources have become active that will affect the communciations simulation. If this is true, it will be necessary to recompute the path transfer function.

4.3.3.2 DETERMINE TRANSMITTER CHARACTERISTICS

This is a series of modules, one for each type of transmitter. A module determines the characteristics for a particular transmitter. This is then used to calculate routing and receive times.

4.3.3.3 LOOK FOR INTENDED RECEIVERS

This module sets up the matrix which defines the receivers and the paths to those receivers for this particular transmission.

4.3.3.4 CALCULATE RECEPTION TIMES

This module calculates a vacuum reception time for each receiver identified by the CONNECTIVITY_MATRIX. An event is generated for each receiver to simulate the reception of the message, and the event is put into EVENT_Q.

4.3.3.5 PATH TRANSFER FUNCTION

This module computes the transform for the communciation path, including composite transforms, when required.

```
 1
 2
 3 ------------------------------------------------------------------------
 4          COMM - COMMUNICATIONS
 5            4.3.1
 6          --------------------
 7
 8          FUNCTION - THIS FUNCTION SIMULATES COMMUNICATIONS
 9            BETWEEN VARIOUS ASSETS USED IN THE SIMULATION.
10            MULTIPATH EFFECTS WILL BE SIMULATED.
11            ENVIRONMENTAL EFFECTS ARE ALSO
12            ACCOUNTED FOR,E.G., WEATHER, NUCLEAR.
13
14          INPUT
15            EVENT_DESC - THE EVENT DRIVING THIS ACTIVITY
16
17          OUTPUT
18            NONE
19
20          ------------------------------------------------------------
21          COMM (EVENT_DESC)
22
23          GET EVENT FROM EVENT_Q (EVENT_DESC, EVENT_DATA)
24          if this is a transmit event, then
25                /*4.3.2 - transmitter transfer function*/
26            call ttf (event)
27                /*4.3.3 - calculate path functions*/
28            call cpf (event)
29          else  /*receive event*/
30                /*4.3.3 - calculate path functions*/
31            call cpf (event)
32                /*4.3.4 - apply path function*/
33            call apf (event, incident_packet)
34                /*4.3.5 - receiver transfer function*/
35            call rtf (event, incident packet)
36          end if
37
38          END  /*COMM*/
39
40
41 ------------------------------------------------------------------------
42          TTF - TRANSMITTER TRANSFER FUNCTION
43            4.3.2
44          ---------------------------------
45
46          FUNCTION - THIS MODULE USES THE TRANSMITTER STATE_VECTOR
47            INCLUDING DAMAGE PARAMETERS TO TRANSFORM AN
```

```
48          INTENDED_PACKET INTO THE TRANSMITTED PACKET.
49
50        INPUT
51          EVENT - THE  EVENT DRIVING THIS ACTIVITY
52
53        OUTPUT
54          NONE
55
56        ------------------------------------------------------
57        TTF (EVENT)
58
59        CASE (MODE)
60          WHEN (FIRST_STEP)
61            IF TIME OF NEXT STEP < TIME OF FINAL EVENT, THEN
62              BUILD EVENT FOR FIRST STEP
63              PUT INTO EVENT_Q (EVENT_DATA)
64            END IF
65
66          WHEN (PARTIAL ! STEP ! LAST_STEP ! INSTANT)
67
68            get transmitter state_vector from real_world
69            get intended packet from info_packet
70            get damage parameters from state_vector
71            calculate transmitter transfer function (damage)
72            transmitted_packet = intended_packet * transmitter transfer
73                                                   function
74            put transmitted_packet into info_packets
75
76            IF MODE = STEP & calculation will continue &
77               TIME OF NEXT STEP < TIME OF FINAL EVENT, THEN
78              BUILD EVENT FOR NEXT STEP (EVENT_DATA)
79              PUT INTO EVENT_Q (EVENT_DATA)
80            END IF
81
82          OTHERWISE
83            ERROR
84
85        END CASE
86        END  /*TTF*/
87
88
89    ------------------------------------------------------------------
90        CPF - CALCULATE PATH FUNCTION
91          4.3.3
92        ---------------------------
93
94        FUNCTION - THIS MODULE COMPUTES THE TRANSFORM FOR THE
95          COMMUNICATION PATH.
96
```

```
97          INPUT
98            EVENT - THE EVENT DRIVING THIS ACTIVITY
99
100         OUTPUT
101           NONE
102
103         ------------------------------------------
104         CPF (EVENT)
105
106         get connectivity matrices [old] & [new]
107         get transmitter state_vector from real_world
108         if this is a receive event, then
109           do for each sector in [new]
110             search sector for sources
111             write sources in [new]
112           end do
113         end if
114              /*4.3.3.1 - check for new sources*/
115         call cns (event; new_source, first_transmit)
116         if new_source = true, then
117           if first_transmit = true, then
118                 /*4.3.3.2 - determine transmitter characteristics*/
119             call dtc (event, state_vector, trans_characteristics)
120                 /*4.3.3.3 - look for intended receivers*/
121             call lfir (event, trans_characteristics, state_vector)
122           end if
123           if this is a transmit event, then
124             do for each sector in [old]
125               search sector for sources
126               write sources in [old]
127             end do
128                 /*4.3.3.4 - calculate reception times*/
129             call crt (event, state_vector)
130           else
131                 /*4.3.3.5 -  path transfer function*/
132             call ptf (event, state_vector)
133           end if
134         end if
135
136         END /*CPF*/
137
138
139 ---------------------------------------------------------------
140         APF - APPLY PATH FUNCTION
141           4.3.4
142         ----------------------------------
143
144         FUNCTION
145           THIS MODULE DOES THE ACTUAL CONVOLUTION OF THE
```

```
146           PATH TRANSFER FUNCTION WITH THE TRANSMITTED_PACKET
147           TO GIVE THE INCIDENT_PACKET.
148
149         INPUT
150           EVENT - THE EVENT DRIVING THIS ACTIVITY
151
152         OUTPUT
153           INCIDENT_PACKET - THE PACKET ACTUALLY DELIVERED BY THE
154                             COMMUNICATION PATH
155
156         ------------------------------------------------------------
157         APF (EVENT, INCIDENT_PACKET)
158
159         get transmitted_packet from info_packets
160         get path transfer function from path_functions
161         incident_packet = transmitted_packet * path transfer function
162
163         END  /*APF*/
164 ------------------------------------------------------------------------
165         RTF - RECEIVER TRANSFER FUNCTION
166           4.3.5
167         ------------------------------
168
169         FUNCTION - THIS MODULE USES THE RECEIVER STATE_ VECTOR
170           INCLUDING DAMAGE PARAMETERS TO TRANSFORM THE
171           INCIDENT_PACKET TO THE RECEIVED_PACKET
172
173         INPUT
174           EVENT - THE EVENT DRIVING THIS ACTIVITY
175           INCIDENT_PACKET - THE PACKET RECEIVED AT THE RECEIVER
176
177         OUTPUT
178           NONE
179
180         -----------------------------------------
181         RTF (EVENT, INCIDENT_PACKET)
182
183         CASE (MODE)
184           WHEN (FIRST_STEP)
185             IF TIME OF NEXT STEP < TIME OF FINAL EVENT, THEN
186               BUILD EVENT FOR FIRST STEP
187               PUT INTO EVENT_Q (EVENT_DATA)
188             END IF
189
190           WHEN (PARTIAL ! STEP ! LAST_STEP ! INSTANT)
191
192             get receiver state_vector from real world
193             get damage from state_vector
194             calculate receiver transfer function (damage)
```

```
195             received_packet = incident_packet *
196                               receiver transfer function
197             add received_packet to info_packets
198             build event to send received_packet
199               to next destination (event_data)
200             put into event_q (event_data)
201
202             IF MODE = STEP & calculation will continue &
203                TIME OF NEXT STEP < TIME OF FINAL EVENT, THEN
204               BUILD EVENT FOR NEXT STEP (EVENT_DATA)
205               PUT INTO EVENT_Q (EVENT_DATA)
206             END IF
207
208           OTHERWISE
209             ERROR
210
211         END CASE
212
213         END  /*RTF*/
214
215
216 ------------------------------------------------------------------
217         CNS - CHECK FOR NEW SOURCES
218           4.3.3.1
219         -------------------------------
220
221         FUNCTION - THIS MODULE DETERMINES IF SOME NEW SOURCE
222           HAS BECOME ACTIVE THAT MIGHT AFFECT COMMUNICATIONS.
223
224         INPUT
225           EVENT - THE EVENT DRIVING THIS ACTIVITY
226
227         OUTPUT
228           NEW_SOURCE - LOGICAL VARIABLE DENOTING THE PRESENCE
229                        OF NEW INTERFERENCE SOURCES
230           FIRST_TRANSMIT - LOGICAL VARIABLE DENOTING FIRST TRANSMISSION
231
232         DEFINITIONS:
233            [...] DENOTES A MATRIX
234            |||[...]|| DENOTES THE NORM OF A MATRIX
235
236         ------------------------------------------------------
237         CNS (EVENT; NEW_SOURCE, FIRST_TRANSMIT)
238
239         check connectivity submatrix [new] for emptiness
240         if empty, then
241           new_source = true
242           first_transmit = true
243         else
```

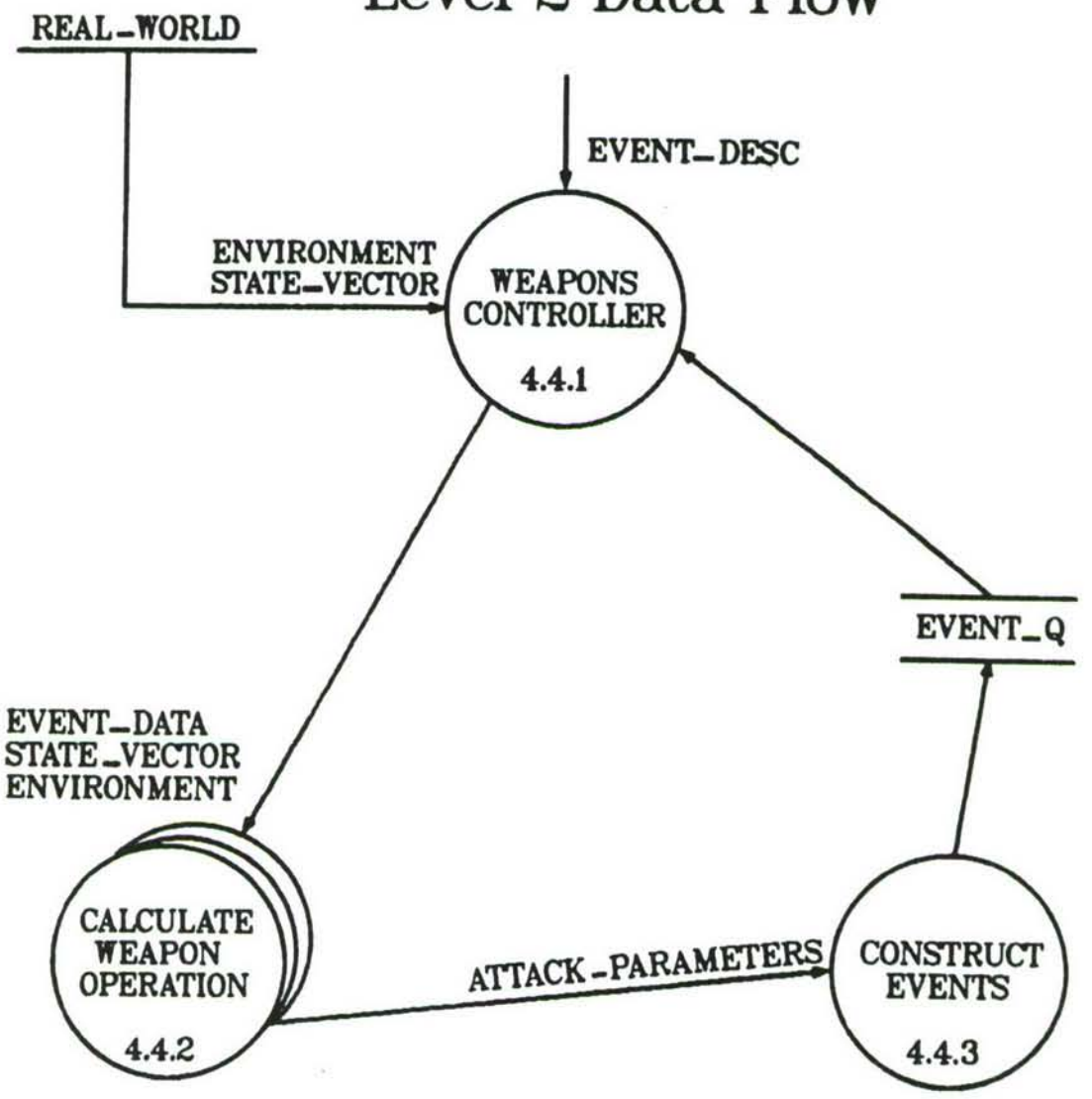
```
244           if  ||[old]-[new]|| > 0 , then
245             new_source = true
246             flag active sources in [new]
247             flag active sectors in [new]
248           else
249             new_source = false
250           end if
251           first_transmit = false
252         end if
253
254         END  /*CNS*/
255
256
257 ------------------------------------------------------------------
258         DTC - DETERMINE TRANSMITTER CHARACTERISTICS
259           4.3.3.2
260         ----------------------------------------
261
262         FUNCTION - THIS MODULE DETERMINES THE CHARACTERISTICS
263           FOR SOME PARTICULAR COMMUNICATION TRANSMITTER
264
265         INPUT
266           EVENT - THE EVENT DRIVING THIS ACTIVITY
267           STATE_VECTOR - THE TRANSMITTER STATE_VECTOR
268
269         OUTPUT
270           TRANS_CHARACTERISTICS - CHARACTERISTICS FOR A TRANSMITTER
271
272         ------------------------------------------------------------
273         DTC (EVENT, STATE_VECTOR, TRANS_CHARACTERISTICS)
274
275         END  /*DTC*/
276
277
278 ------------------------------------------------------------------------
279         LFIR - LOOK FOR INTENDED RECEIVERS
280           4.3.3.3
281         ------------------------------------------------
282
283         FUNCTION - THIS MODULE ADDS TO THE CONNECTIVITY MATRIX
284           THAT DEFINES THE PATHS AND RECEIVERS FOR A PARTICULAR
285           TRANSMITTER. "OLD" AND "NEW" VERSIONS OF THE MATRIX ARE
286           WRITTEN TO A FILE. BOTH "OLD" AND "NEW" MATRICES MUST
287           BE INITIALIZED AT THE BEGINNING OF THE SIMULATION.
288
289         DEFINITIONS -
290           tbnd = transmitter frequency band
291           rbnd = receiver frequency band
292
```

```
293          INPUT
294            EVENT - THE EVENT DRIVING THIS ACTIVITY
295            TRANS_CHARACTERISTICS - CHARACTERISTICS FOR TRANSMITTER
296            STATE_VECTOR - THE TRANSMITTER STATE_ VECTOR
297
298          OUTPUT
299            NONE
300
301          ------------------------------------------------------
302          LFIR (EVENT, TRANS_CHARACTERISTICS, STATE_VECTOR)
303
304          get trans_sv from real_world
305          parse trans_sv for frequency characteristics (trans_sv; tbnd)
306          get intended receiver list from event_desc
307          do for all intended receivers
308            get rec_sv from real_world
309            parse rec_sv for frequency characteristics (rec_sv; rbnd)
310            if tbnd within rbnd, then
311              set path = no
312              check transrec pair for los (trans_sv, rec_sv)
313              if los = yes, then
314                write receiver_id in connectivity matrices [old] & [new]
315                find sectors along los
316                write sectors in connectivity matrices [old] & [new]
317                set path = direct
318                write path in connectivity matrices [old] & [new]
319              end if
320              check for additional paths /*do waveguides exist?*/
321              do for each alternate path
322                write receiver_ID in connectivity matrices [old] & [new]
323                find sectors along alternate path
324                write sectors in connectivity matrices [old] & [new]
325                set path = indirect
326                write path in connectivity matrices [old] & [new]
327              end do
328              if path = no, then
329                write ''no path" message
330              end if
331            else
332              write ''ineligible receiver" message
333            end if
334          end do
335
336          END  /*LFIR*/
337
338
339 ---------------------------------------------------------------------
340          CRT - CALCULATE RECEPTION TIMES
341            4.3.3.4
```

```
342         ---------------------------------
343
344         FUNCTION - THIS MODULE CALCULATES A RECEPTION TIME
345           FOR EACH RECEIVER_IDENTIFIED BY THE
346           CONNECTIVITY_MATRIX.  EVENTS ARE BUILT AND PUT INTO
347           THE EVENT_Q TO SIMULATE THE RECEPTION OF THE MESSAGES.
348
349         INPUT
350           EVENT - THE EVENT DRIVING THIS ACTIVITY
351           STATE_VECTOR - THE TRANSMITTER STATE_ VECTOR
352
353         OUTPUT
354           NONE
355
356         -------------------------------------------------
357         CRT (EVENT, STATE_VECTOR)
358
359         ttrn = time from event data
360         get transmitter_sv and geography from real_world
361         get conn_matrix
362         do for each receiver in connectivity matrix
363           get receiver_sv from real_world
364           do for each path
365             calculate vacuum transit time
366             build event to simulate reception (event_data)
367             put into event_q (event_data)
368           end do
369         end do
370
371
372         END  /*CRT*/
373
374
375     ------------------------------------------------------------
376         PTF -  PATH TRANSFER FUNCTION
377           4.3.3.5
378         --------------------------
379
380         FUNCTION - THIS MODULE COMPUTES THE TRANSFORM FOR THE
381           COMMUNICATION PATH.
382
383         INPUT
384           EVENT - THE EVENT DRIVING THIS ACTIVITY
385           STATE_VECTOR - THE TRANSMITTER STATE_ VECTOR
386
387         OUTPUT
388           NONE
389
390         -------------------------------------------
```

```
391         PTF (EVENT, STATE_VECTOR)
392
393         get path lengths and directions from connectivity_matrix [new]
394         calculate hard link parameters
395         calculate soft link parameters  /*primary and secondary paths,
396                                           over or in land and water
397                                                 or ice*/
398         get weather sources from [new]
399         calculate weather perturbations  /*solar and terrestrial*/
400         get nuclear effects sources from connectivity_matrix [new]
401         calculate nuclear effects perturbations
402         calculate path transfer function
403         put path transfer function into path_functions
404
405         END  /*PTF*/
406
```

4.4 WEAPONS
Level 2 Data Flow



4.4.1 WEAPONS CONTROLLER

There is a weapon's module or process for each type of weapon. The controller does the standard functions of getting data from the REAL_WORLD, getting and building EVENTs, and determining which weapon modules to call.

4.4.2 CALCULATE WEAPON OPERATION

This series of modules uses the EVENT_DATA to calculate ATTACK_PARAMETERS that completely and parametrically describe the operation of the weapon. They may also identify future weapon operation that must be calculated.

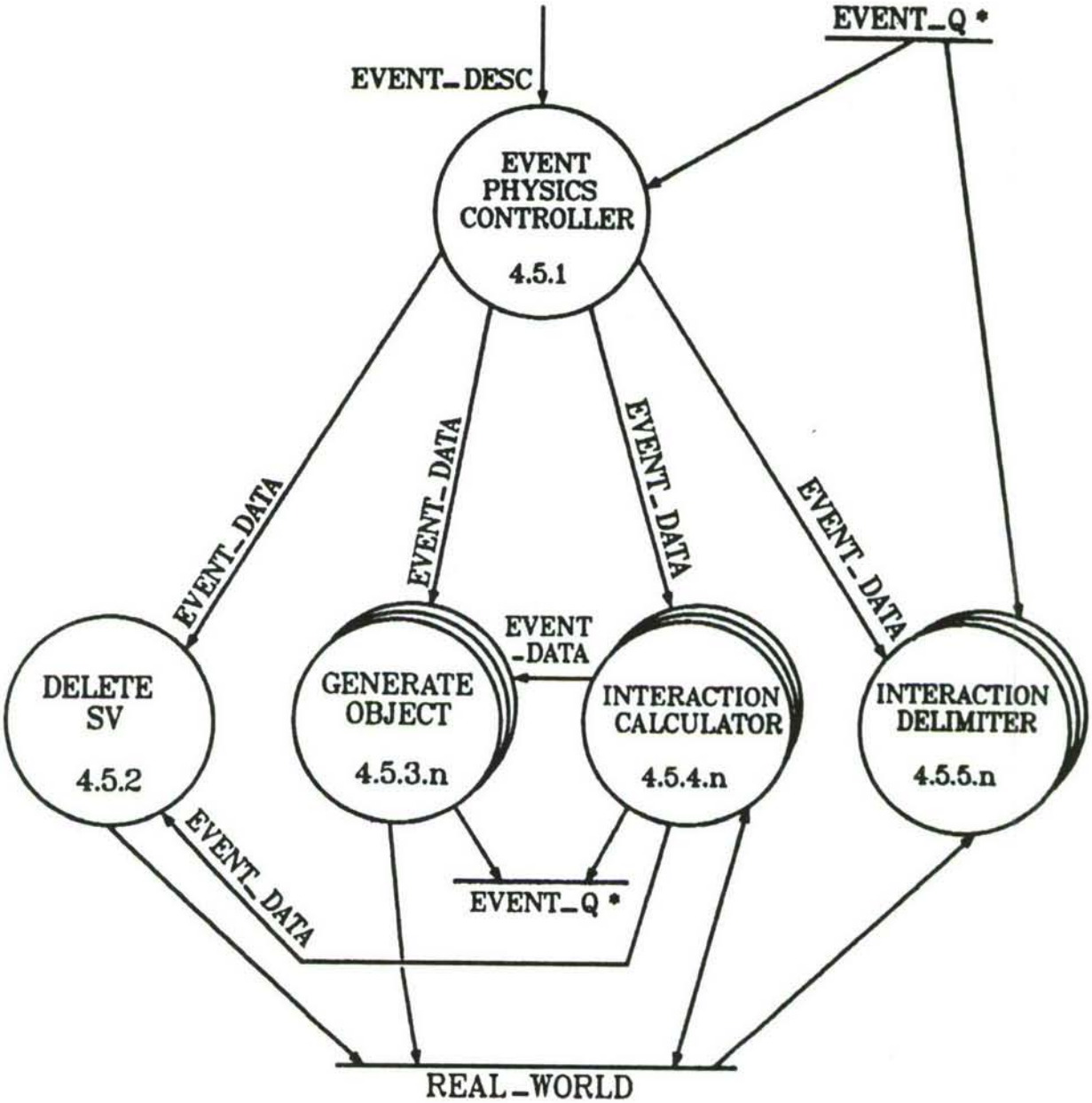
4.4.3 CONSTRUCT EVENTS

This module constructs EVENTs using ATTACK_PARAMETERS. The events are used to call Event Physics immediately or to recall the required weapon's module.

```
 1
 2
 3 ------------------------------------------------------------------
 4          WEAPONS - SIMULATE WEAPONS
 5            4.4.1
 6          ----------------------------------
 7
 8          FUNCTION
 9            THE WEAPON'S MODULE CALCULATES THE ACTUAL FUNCTION
10            FOR A WEAPON SUCH AS YIELD FOR A BOMB
11            OR BEAM DURATION AND INTENSITY FOR A LASER.
12
13          INPUT
14            EVENT_DESC - THE EVENT DRIVING THIS ACTIVITY
15
16          OUTPUT
17            NONE
18
19          ------------------------------------------------------------
20          WEAPONS (EVENT_DESC)
21
22          get event from event_q (event_desc, event_data)
23
24          CASE (MODE)
25            WHEN (FIRST_STEP)
26              IF TIME OF NEXT STEP < TIME OF FINAL EVENT, THEN
27                BUILD EVENT FOR FIRST STEP
28                PUT INTO EVENT_Q (EVENT_DATA)
29              END IF
30
31            WHEN (PARTIAL ! STEP ! LAST_STEP ! INSTANT)
32
33              get state_vector for this weapon from real_world
34              get this weapon's environment from real_world
35              /*4.4.2*/
36              calculate operation for this weapon (state_vector,
37                                                   event_data, environment,
38                                                   attack_parameters)
39
40              /*4.4.3 - construct events*/
41              if weapon must function at a later time
42                build event to continue function (attack_parameters,
43                                                  event_data)
44                add to event_q (event_data)
45              end if
46              build event to execute event physics immediately (event_data)
```

```
47              add to event_q (event_data)
48              /*end 4.4.3*/
49
50              IF MODE = STEP & calculation is to continue &
51                 TIME OF NEXT STEP < TIME OF FINAL EVENT, THEN
52                BUILD EVENT FOR NEXT STEP (EVENT_DATA)
53                PUT INTO EVENT_Q (EVENT_DATA)
54              END IF
55
56            OTHERWISE
57              ERROR
58          END CASE
59
60          END  /*WEAPONS*/
```

4.5 PHYSICS
Level 2 Data Flow



4.5 EVENT PHYSICS

4.5.1 EVENT PHYSICS CONTROLLER

This module uses the EVENT_DESC given to it by the Executive to get the appropriate EVENT_DATA. It then uses information extracted from the EVENT_DATA to call the appropriate module to perform the event.

4.5.2 DELETE SV

This module extracts a SV_ID from the EVENT_DATA and deletes the STATE_VECTOR with this ID from the REAL_WORLD file.

4.5.3.n GENERATE OBJECT

This is a series of modules, each of which uses parameters from EVENT_DATA to create a complete parameter set for a new object. It converts this parameter set into STATE_VECTOR format and stores the STATE_VECTOR in the REAL_WORLD file.

4.5.4.n INTERACTION CALCULATOR

This is a series of modules, each of which calculates a type of force-on-asset interaction. Each module is conceptually of the "zeroth-order convolution" optionally followed by "interaction loops" that refine the zeroth-order calculations.

4.5.5.n INTERACTION DELIMITER

This is a set of modules, each of which accomplishes the following for a particular effect type:

1) identifies affected assets
2) creates EVENTs to trigger the interaction calculations.

In the process of identifying the affected assets, it may update object positions and/or conditions beyond the last Mother Nature call, but these updates will not be stored in the REAL_WORLD file.

```
1
2
3 ------------------------------------------------------------
4          EP - EVENT PHYSICS
5            4.5.1
6          ----------------------------------
7
8          FUNCTION
9            THIS MODULE GETS THE EVENT INFORMATION AND THEN SELECTS
10           THE MODULE REQUIRED TO EXECUTE THE EVENT.
11
12         INPUT
13           EVENT_DESC - POINTER TO THE EVENT DRIVING THIS ACTIVITY
14
15         OUTPUT
16           NONE
17
18         ------------------------------------------------------------
19         EP (EVENT_DESC)
20
21         get event from event_q (event_desc, event_data)
22         extract ep_type from event_data
23         case (ep_type)
24           when (delete_sv)
25                 /*4.5.2 - delete state vector*/
26             call delsv (event_data)
27           when (generate_object)
28             extract object_type from event_data
29             case object_type
30               when (object_type n)
31                     /*4.5.3.n - generate object*/
32                 call genobj (event_data)
33               .
34               .
35               .
36             end case
37           when (interaction)
38             extract interaction_type from event_data
39             case (interaction_type)
40               when (interaction_type n)
41                     /*4.5.4.n - interaction calculator*/
42                 call incalul (event)
43               .
44               .
45               .
46             end case
47           when (interaction_delimiter)
```

```
48              extract interaction_delimiter_type from event_data
49              case (interaction_delimiter_type)
50                when (interaction_delimiter_type n)
51                       /*4.5.5.n - interaction delimiter*/
52                  call indelim (event_data)
53                .
54                .
55                .
56              end case
57          end case
58
59          END  /*EP*/
60
61
62 ------------------------------------------------------------------
63          DELSV - DELETE STATE VECTOR
64            4.5.2
65          ----------------------------------
66
67          FUNCTION
68            THIS MODULE FINDS THE IDENTIFICATION AND
69            LOCATION OF THE STATE_VECTOR AND DELETES IT FROM
70            THE REAL_WORLD.
71
72          INPUT
73            EVENT_DATA - THE EVENT DEFINING THE STATE VECTOR TO DELETE
74
75          OUTPUT
76            NONE
77
78          ------------------------------------------------------------
79          DELSV (EVENT_DATA)
80
81          extract sv_id from event_data
82          find state_vector in real_world (sv_id)
83          delete state_vector from real_world (sv_id)
84
85          END  /*DELSV*/
86
87
88 ------------------------------------------------------------------
89          GENOBJ - GENERATE OBJECT
90            4.5.3.n
91          ----------------------------------
92
93          FUNCTION
94            THIS MODULE USES THE PARAMETERS FROM EVENT_DATA TO
95            CREATE THE PARAMETER SET FOR A NEWLY CREATED OBJECT.
96            THESE PARAMETERS ARE STORED IN STATE_VECTOR FORMAT
```

```
97            IN REAL_WORLD.
98
99          INPUT
100           EVENT_DATA - THE EVENT CAUSING THE OBJECT TO BE CREATED
101
102         OUTPUT
103           NONE
104
105         ------------------------------------------------------------
106         GENOBJ (EVENT_DATA)
107
108         generate object
109         construct state_vector
110         put state_vector into real_world
111         if object requires mother nature update, then
112           build event to run mother nature (event_data)
113           put into event_q (event_data)
114         end if
115
116         END  /*GENOBJ*/
117
118
119 ------------------------------------------------------------
120         INCALUL - INTERACTION CALCULATOR
121           4.5.4.n
122         ----------------------------------
123
124         FUNCTION
125           THIS MODULE CALCULATES A TYPE OF FORCE ON ASSET
126           INTERACOCTION.  CONCEPTUALLY THIS IS A ZEROTH-ORDER
127           CONVOLUTION OPTIONALLY FOLLOWED BY INTERACTION
128           LOOPS THAT REFINE THE ZEROTH_ORDER CALCULATION.
129
130         INPUT
131           EVENT - THE EVENT DEFINING THE CALCULATION
132
133         OUTPUT
134           NONE
135
136         ------------------------------------------------------------
137         INCALCU (EVENT)
138
139         CASE (MODE)
140           WHEN (FIRST_STEP)
141             IF TIME OF NEXT STEP < TIME OF FINAL EVENT, THEN
142               CALCULATE TIME OF FIRST STEP
143               BUILD EVENT FOR FIRST STEP
144               PUT INTO EVENT_Q (EVENT_DATA)
145             END IF
```

```
146
147           WHEN (PARTIAL ! STEP ! LAST_STEP ! INSTANT)
148
149             get state_vectors, geography, environment from real world
150             update fast state_vectors, fast environment components
151             do zeroth order convolution
152             do interaction loops to refine zeroth order
153             modify state_vector to reflect new damage parameters
154             replace state_vector in real_world with modified state_vector
155             if interaction calculation spawned new objects
156               do for each new object
157                 construct event_data to do generation
158                      /*4.5.3 - generate object*/
159                 call genobj (event_data)
160               end do
161             end if
162             if interaction calculation required deletion of objects
163               do for each object to be deleted
164                 construct event_data for deletion
165                      /*4.5.2 - delete state vector*/
166                 call delsv (event_data)
167               end do
168             end if
169
170             IF MODE = STEP & calculation will continue &
171                TIME OF NEXT STEP < TIME OF FINAL EVENT, THEN
172               CALCULATE TIME OF NEXT STEP
173               BUILD EVENT FOR NEXT STEP (EVENT_DATA)
174               PUT INTO EVENT_Q (EVENT_DATA)
175             END IF
176
177           OTHERWISE
178             ERROR
179
180         END CASE
181
182         END  /*INCALCU*/
183
184
185 ------------------------------------------------------------
186         INDELIM - INTERACTION DELIMITER
187           4.5.5.n
188         ----------------------------------
189
190         FUNCTION
191           FOR A PARTICULAR EFFECT TYPE, THIS MODULE IDENTIFIES
192           AFFECTED ASSETS AND CREATES EVENTS TO TRIGGER THE
193           INTERACTION CALCULATIONS.  THE IDENTIFICATION PROCESS
194           MAY REQUIRE THAT OBJECT POSITIONS OR
```

```
195           CONDITONS BE UPDATED BEYOND THE POINT OF THE LAST MOTHER
196           NATURE CALL.  THESE UPDATES HOWEVER ARE NOT SAVED IN
197           THE REAL_WORLD.
198
199         INPUT
200           EVENT_DATA - THE DATA DEFINING THE INTERACTON
201
202         OUTPUT
203           NONE
204
205         ------------------------------------------------------------
206         INDELIM (EVENT_DATA)
207
208         get state_vectors, geography, environment from real_world
209         update fast state_vectors, fast environment components
210         do for each state_vector in question
211           decide if it will interact
212           if it will interact
213             find out when it will interact
214             construct event to do the interaction
215             put event in the event_q
216           end if
217         end do
218
219         END  /*INDELIM*/
```

8. DATA DEFINITIONS

DATA DEFINITIONS	PAGE
ATTACK_PARAMETERS	8-4
ATTACK_PLAN	8-4
BATTLE_MGR_DIRECTIVE	8-4
CMD_ATTACK_PLAN	8-4
CMD_ENVIRONMENT	8-5
CMD_GEOGRAPHY	8-5
CMD_INTERVENTIONS	8-5
CMD_MODULES	8-6
CMD_ORDER_OF_BATTLE	8-6
CMD_OUTPUT_SPECS	8-6
CMD_PLANNED_RESPONSES	8-7
CMD_PROMPT	8-7
CMDS	8-7
CODE_DATA	8-8
CODE_STATUS	8-8
CONFLICT	8-8
CONFLICT_LIST	8-9
CONNECTIVITY_MATRIX	8-9
CONSTANTS	8-10
DAMAGE	8-10
DATE_TIME	8-10
DESTINATION	8-11
DISPLAY	8-11
DO_EVENT	8-11
DO_NOW	8-12
ENVIRONMENT	8-12
EP_TYPE	8-12
ERROR_MSG	8-13
EV_DATA	8-13
EVENT	8-14
EVENT_DATA (generic)	8-14
EVENT_DATA_PTR	8-14
EVENT_DESC	8-15
EVENT_Q	8-15
FIRST_TRANSMIT	8-16
GEOGRAPHY	8-16
GLOBAL_SIMULATION_DATA	8-16
GRID_QUANTITY	8-16
INCIDENT_PACKET	8-17
INFO_DATA	8-17
INFO_PACKETS	8-17
INFO_PTR	8-18
IN_PROGRESS	8-18
INTENDED_PACKET	8-18
INTERACTION_DELIMITER_TYPE	8-19
INTERACTION_TYPE	8-19
INTERRUPT	8-19

INTERVENTIONS	8-20
MENU	8-20
MN_AGAIN	8-21
MN_EVENT_PARAMETERS	8-21
MN_GEOGRAPHY	8-21
MN_GEOGRAPHY_REQUEST	8-22
MN_SOURCES	8-22
MODE	8-22
MODULE_LIBRARY	8-23
MODULE_NAME	8-23
MSG_CODE	8-24
MSG_TEXT	8-24
NEXT_TIME	8-24
NEW_SOURCE	8-25
OBJECT_TYPE	8-25
ORDER_OF_BATTLE	8-25
ORIENTATION	8-25
OUTPUT_LOG	8-26
PACKET (generic)	8-26
PATH_FUNCTIONS	8-27
PERCEIVED_ATTRIBUTES	8-27
PERCEIVED_OBJECT_ATTRIBUTES	8-27
PERCEIVED_WORLDS	8-28
PHYSICAL_OUTPUT	8-28
PLANNED_RESPONSE	8-28
POSITION	8-29
POST_PROCESSING	8-29
PREV_TIME	8-29
REAL_WORLD	8-30
RECEIVED_PACKET	8-30
RECEIVED_ID	8-30
RECORDED_DECISION	8-31
RECORDED_OBSERVATION	8-31
REF_LIBRARY	8-31
RESTART_DUMPS	8-32
SAVE_SV	8-32
SCENARIO	8-32
SCENARIO_LIBRARY	8-33
SENSOR_OPERATING_PARAMETERS	8-33
SIM_DATA	8-34
SIM_STATUS	8-34
SOURCE	8-34
STATE_VECTOR (generic)	8-35
SV_CLASS_ID	8-35
SV_ID	8-35
SYSTEM_TABLES	8-36
TEXT_MSG	8-36
TIME	8-36
TRANS_CHARACTERISTICS	8-37

TRANSMITTED_PACKET 8-37
TRANSMITTER_ID 8-37
VIEWABLE_OBJECT_LIST 8-38
WARNING_MSG 8-38

NAME: ATTACK_PARAMETERS

ALIASES:

TYPE: DATA ELEMENT | DATA FLOW| FILE

DESCRIPTION: This is information describing how a weapon functions (e.g. yield, duration) for inclusion in EVENT_DATA.

COMPOSITION:

ORGANIZATION (if file):

NOTES:

NAME: ATTACK_PLAN

ALIASES:

TYPE: DATA ELEMENT | DATA FLOW| FILE

DESCRIPTION: Offensive plans for the battle managers.

COMPOSITION:

ORGANIZATION (if file):

NOTES:

NAME: BATTLE_MGR_DIRECTIVE

ALIASES:

TYPE: DATA ELEMENT | DATA FLOW| FILE

DESCRIPTION: A recorded order sent by a battle manager to some device under its control.

COMPOSITION: EVENT

ORGANIZATION (if file):

NOTES:

NAME: CMD_ATTACK_PLAN

ALIASES:

TYPE: DATA ELEMENT | DATA FLOW| FILE

DESCRIPTION: The user commands to specify the attack plan.

COMPOSITION:

ORGANIZATION (if file):

NOTES:

NAME: CMD_ENVIRONMENT

ALIASES:

TYPE: DATA ELEMENT | DATA FLOW| FILE

DESCRIPTION: These are the user commands to specify the environment for the simulation.

COMPOSITION:

ORGANIZATION (if file):

NOTES:

NAME: CMD_GEOGRAPHY

ALIASES:

TYPE: DATA ELEMENT | DATA FLOW| FILE

DESCRIPTION: These are the user commands to specify the geography.

COMPOSITION:

ORGANIZATION (if file):

NOTES:

NAME: CMD_INTERVENTIONS

ALIASES:

TYPE: DATA ELEMENT | DATA FLOW| FILE

DESCRIPTION: These are the user commands to specify events or actions that interrupt, change, override, or report on activities.

COMPOSITION:

ORGANIZATION (if file):

NOTES:

NAME: CMD_MODULES

ALIASES:

TYPE: DATA ELEMENT | DATA FLOW| FILE

DESCRIPTION: These are the user commands used to select the particular code modules to be used for the simulation. The code modules selected will define the fidelity of the simulation.

COMPOSITION:

ORGANIZATION (if file):

NOTES:

NAME: CMD_ORDER_OF_BATTLE

ALIASES:

TYPE: DATA ELEMENT | DATA FLOW| FILE

DESCRIPTION: The user commands to specify the initial order of battle including equipment and forces.

COMPOSITION:

ORGANIZATION (if file):

NOTES:

NAME: CMD_OUTPUT_SPECS

ALIASES:

TYPE: DATA ELEMENT | DATA FLOW| FILE

DESCRIPTION: These are the user commands used to define the output that the simulation is to collect and present.

COMPOSITION:

ORGANIZATION (if file):

NOTES:

NAME: CMD_PLANNED_RESPONSES

ALIASES:

TYPE: DATA ELEMENT | DATA FLOW| FILE

DESCRIPTION: These are the user commands that specify and select the defensive plans for the battle manager.

COMPOSITION:

ORGANIZATION (if file):

NOTES:

NAME: CMD_PROMPT

ALIASES:

TYPE: DATA ELEMENT | DATA FLOW| FILE

DESCRIPTION: These are the prompts that assist the user in deciding what to do next.

COMPOSITION:

ORGANIZATION (if file):

NOTES:

NAME: CMDS

ALIASES:

TYPE: DATA ELEMENT | DATA FLOW| FILE

DESCRIPTION: These are the commands that allow the user to setup, run, and observe the code and simulation.

COMPOSITION:

```
{CMD_ORDER_OF_BATTLE /* the initial order of
battle - this includes equipment and forces */
+ CMD_ATTACK_PLAN + CMD_PLANNED_RESPONSES}
+ {CMD_INTERVENTION} /* events to trigger natural
```

```
            and man-imposed actions */
            + CMD_MODULES + CMD_GEOGRAPHY + CMD_ENVIRONMENT
            + CMD_OUTPUT_SPECS
```

ORGANIZATION (if file):

NOTES: Model fidelity is determined by the selection of modules for the simulation. For most cases fidelity will be mixed.

NAME: CODE_DATA

ALIASES:

TYPE: DATA ELEMENT | DATA FLOW | FILE

DESCRIPTION: This is information that defines the state or status of the simulation program.

COMPOSITION: binary representation of code system status as to written the POST_PROCESSING and RESTART_DUMPS files.

ORGANIZATION (if file):

NOTES: The CODE_DATA definition applies to binary machine representation of data that the user has requested.

NAME: CODE_STATUS

ALIASES:

TYPE: DATA ELEMENT | DATA FLOW| FILE

DESCRIPTION: This is the status or state of the actual simulation program -not the simulation -as displayed for the user.

COMPOSITION: Text representation of the CODE_DATA data definition.

ORGANIZATION (if file):

NOTES: The CODE_STATUS definition applies to text representation of data that the user has requested.

NAME: CONFLICT

ALIASES:

TYPE: DATA ELEMENT| DATA FLOW | FILE

DESCRIPTION: This is a flag that defines whether a conflict exists or not.

COMPOSITION: TRUE | FALSE

TRUE - a conflict exists
FALSE - no conflict

ORGANIZATION (if file):

NOTES:

NAME: CONFLICT_LIST

ALIASES:

TYPE: DATA ELEMENT | DATA FLOW| FILE

DESCRIPTION: This is a list of entries from the IN_PROGESS file that are in conflict with one of the assets from a particular event.

COMPOSITION: {SV_ID + FINAL_EVENT_PTR}

ORGANIZATION (if file):

NOTES:

NAME: CONNECTIVITY_MATRIX

ALIASES:

TYPE: DATA ELEMENT | DATA FLOW | FILE

DESCRIPTION: This matrix which actually is two submatrices contains the possible communication paths and receivers for a packet transmission from a particular transmitter. The most general (high-fidelity) form of the matrix is five-dimensional, with indices (I.J.K.L.M).

I identifies the transmitter,

J identifies the receiver(s),

K identifies the transmission path(s),

L identifies the sector(s) that contain the K-th path, and

M identifies the communications interference sources.

COMPOSITION: old + new

new - submatrix for new transmissions
old - submatrix for existing transmissions.

ORGANIZATION (if file):

NOTES:

NAME: CONSTANTS

ALIASES:

TYPE: DATA ELEMENT | DATA FLOW | FILE

DESCRIPTION: The standard constants used throughout the simulation program:
e.g. pi, the speed of light, etc.

COMPOSITION:

ORGANIZATION (if file):

NOTES: Constants will not be hardcoded into the program. They will be defined once in this file and loaded into the code at initialization time.

NAME: DAMAGE

ALIASES:

TYPE: DATA ELEMENT| DATA FLOW | FILE

DESCRIPTION:This specifies the fraction of damage to an asset.

COMPOSITION:

DEAD = 1 ALIVE = 0 ALIVE $\leq$ DAMAGE $\leq$ DEAD

ORGANIZATION: (if file):

NOTES:

NAME: DATE_TIME

ALIASES:

TYPE: DATA ELEMENT| DATA FLOW | FILE

DESCRIPTION: This is the standard format for text date and time.

COMPOSITION:

ORGANIZATION (if file):

NOTES: We may wish to have this information in many different formats.

NAME: DESTINATION

ALIASES:

TYPE: DATA ELEMENT| DATA FLOW | FILE

DESCRIPTION: This identifies the module to be executed.

COMPOSITION:

ORGANIZATION (if file):

NOTES:

NAME: DISPLAYS

ALIASES:

TYPE: DATA ELEMENT | DATA FLOW| FILE

DESCRIPTION: These are the terminal displays for the user of the simulation.

COMPOSITION:

```
[MENU | CMD_PROMPT] /* prompting via menus or text */
+ CODE_STATUS /* status of the simulation program */
+ SIM_STATUS /* status of the simulated battle-maps,
bar charts, trajectories,etc.  */
```

ORGANIZATION (if file):

NOTES:

NAME: DO_EVENT

ALIASES:

TYPE: DATA ELEMENT| DATA FLOW | FILE

DESCRIPTION: This is a flag returned by the conflict handler to the executive controller indicating whether the new event should be

executed or not.

COMPOSITION: TRUE | FALSE

TRUE - execute event
FALSE - do not execute the event

ORGANIZATION (if file):

NOTES:

NAME: DO_NOW

ALIASES:

TYPE: DATA ELEMENT| DATA FLOW | FILE

DESCRIPTION: This is a flag in an event that indicates whether an event can be executed now or if it must go to the conflict handler first.

COMPOSITION: TRUE | FALSE

ORGANIZATION (if file):

NOTES: TRUE - EVENT can be executed without going to conflict handler
FALSE - EVENT must go to conflict handler.

NAME: ENVIRONMENT

ALIASES:

TYPE: DATA ELEMENT | DATA FLOW | FILE

DESCRIPTION: The physical world's environment.

COMPOSITION: weather + space + eme* + etc

ORGANIZATION (if file):

NOTES: * eme is defined as ElectroMagnetic Environment.

NAME: EP_TYPE

ALIASES:

TYPE: DATA ELEMENT| DATA FLOW | FILE

DESCRIPTION: Part of EVENT_DATA, this parameter denotes which of several types of calculations is to be performed by EVENT_PHYSICS. It may legally acquire the following values:

DELETE_SV
GENERATE_OBJECT
INTERACTION_DELIMITATION
INTERACTION.

COMPOSITION:

ORGANIZATION (if file):

NOTES:

NAME: ERROR_MSG

ALIASES:

TYPE: DATA ELEMENT | DATA FLOW| FILE

DESCRIPTION: The standard format text message put out when the simulation program detects an error.

COMPOSITION: TEXT_MSG

ORGANIZATION (if file):

NOTES:

NAME: EV_DATA

ALIASES:

TYPE: DATA ELEMENT | DATA FLOW| FILE

DESCRIPTION: These are event specific data that are part of the EVENT_DATA definition. Each event type will most likely have a different format for this structure.

COMPOSITION: [PREV_TIME] + event dependent data

ORGANIZATION (if file):

NOTES:

NAME: EVENT

ALIASES:

TYPE: DATA ELEMENT| DATA FLOW | FILE

DESCRIPTION: This is an activity that is to occur at some specific time.

COMPOSITION: EVENT_DESC + EVENT_DATA

ORGANIZATION (if file):

NOTES:

NAME: EVENT_DATA (generic)

ALIASES:

TYPE: DATA ELEMENT | DATA FLOW| FILE

DESCRIPTION: This is the (generic) structure of the data part of the EVENT_Q file. Each event type will most likely have a different EV_DATA format.

COMPOSITION:

```
TIME /* when the event is to take place */
+ SOURCE /* who originated the event */
+ DESTINATION /* module to be executed */
+ EV_DATA /* event specific information */
```

ORGANIZATION (if file):

NOTES:

NAME: EVENT_DATA_PTR

ALIASES:

TYPE: DATA ELEMENT| DATA FLOW | FILE

DESCRIPTION: This is the address of EVENT_DATA in the EVENT_Q file.

COMPOSITION:

ORGANIZATION (if file):

NOTES:

NAME: EVENT_DESC

ALIASES:

TYPE: DATA ELEMENT | DATA FLOW| FILE

DESCRIPTION: This is the structure of the pointer part of the EVENT_Q file.

COMPOSITION:

```
TIME /* when the event is to take place*/
+ EVENT_DATA_PTR /* pointer to the EVENT_DATA entry*/
+ DESTINATION /* to whom the event is destined */
+ {SV_ID} /* the assets involved in the event*/
+ FINAL_EVENT_PTR /* a pointer to the EVENT_DESC of the
final event of an extended event*/
+ DO_NOW /* flag indicating if conflict is
already done and the event can be
executed without going through the
conflict handler*/
+ MODE /* the mode in which the event is to
be calculated */
```

ORGANIZATION (if file):

NOTES: The maximum number of SV_IDs is 2 (two).

NAME: EVENT_Q

ALIASES:

TYPE: DATA ELEMENT | DATA FLOW | FILE

DESCRIPTION: This is a time-ordered series of events used to trigger activities in the simulation.

COMPOSITION: EVENT

ORGANIZATION (if file):

ORGANIZATION (if file): The file consists of a data section in arbitrary order and a compact time-ordered list pointing to entries in the data section.

NOTES:

NAME: FIRST_TRANSMIT

ALIASES

TYPE: DATA ELEMENT | DATA FLOW| FILE

DESCRIPTION: This is a logical variable denoting first communication transmission.

COMPOSITION: TRUE | FALSE

ORGANIZATION: (if file):

NOTES:

NAME: GEOGRAPHY

ALIASES:

TYPE: DATA ELEMENT | DATA FLOW | FILE

DESCRIPTION: This is a map of the world defined to the extent needed for the simulation.

COMPOSITION:

ORGANIZATION (if file):

NOTES:

NAME: GLOBAL_SIMULATION_DATA

ALIASES:

TYPE: DATA ELEMENT | DATA FLOW | FILE

DESCRIPTION:

COMPOSITION:

ORGANIZATION (if file):

NOTES: Is this identical or related to SIM_STATUS or SIM_DATA?

NAME: GRID_QUANTITY

ALIASES:

TYPE: DATA ELEMENT | DATA FLOW| FILE

DESCRIPTION: This is a quantity such as electromagnetic environment or nonlocal weather that is stored in DETEC in a discretized fashion, the GRID being the basis for discretization.

COMPOSITION:

ORGANIZATION (if file):

NOTES:

NAME: INCIDENT_PACKET

ALIASES:

TYPE: DATA ELEMENT | DATA FLOW| FILE

DESCRIPTION: This is the communication packet that arrived at the receiver. It is the TRANSMITTED_PACKET modified by the path transfer function. For a perfect communication path, it is identical to the TRANSMITTED_PACKET.

COMPOSITION: PACKET

ORGANIZATION (if file):

NOTES:

NAME: INFO_DATA

ALIASES:

TYPE: DATA ELEMENT | DATA FLOW| FILE

DESCRIPTION: These are the data accompanying an information packet. There probably will be many different formats for these data.

COMPOSITION:

ORGANIZATION (if file):

NOTES: This will include routing information if necessary.

NAME: INFO_PACKETS

ALIASES:

TYPE: DATA ELEMENT | DATA FLOW | FILE

DESCRIPTION: INFO_PACKETS is a file containing messages that are transmitted

from asset to asset.

COMPOSITION: {PACKET}

ORGANIZATION (if file):

NOTES:

NAME: INFO_PTR

ALIASES:

TYPE: DATA ELEMENT| DATA FLOW | FILE

DESCRIPTION: This is the address of INFO_DATA that is part of a packet.

COMPOSITION:

ORGANIZATION (if file):

NOTES:

NAME: IN_PROGRESS

ALIASES:

TYPE: DATA ELEMENT | DATA FLOW | FILE

DESCRIPTION: This is a list of asset identifications for which an extended length simulation is currently being done. It is possible for a single asset to be listed several times.

COMPOSITION:
{SV_ID + FINAL_EVENT_PTR} /* location of final EVENT_PTR in EVENT_Q for an extended event */

ORGANIZATION (if file):

NOTES:

NAME: INTENDED_PACKET

ALIASES:

TYPE: DATA ELEMENT | DATA FLOW| FILE

DESCRIPTION: This is the correct communication packet that the sender

intended to transmit.

COMPOSITION: PACKET

ORGANIZATION (if file):

NOTES:

NAME: INTERACTION_DELIMITER_TYPE

ALIASES:

TYPE: DATA ELEMENT| DATA FLOW | FILE

DESCRIPTION: Part of EVENT_DATA, this parameter indicates which type of effect an interaction delimitation is to be performed.

COMPOSITION:

ORGANIZATION (if file):

NOTES:

NAME: INTERACTION_TYPE

ALIASES:

TYPE: DATA ELEMENT| DATA FLOW | FILE

DESCRIPTION: Part of EVENT_DATA, this parameter indicates which type (effect-on-asset) of interaction is to be calculated.

COMPOSITION:

ORGANIZATION (if file):

NOTES:

NAME: INTERRUPT

ALIASES:

TYPE: DATA ELEMENT| DATA FLOW | FILE

DESCRIPTION: This is a control flag, returned by the executive to the

manager, that indicates the reason the executive is stopping or suspending.

COMPOSITION: INTERVENE | COMPLETE | FATAL_ERROR | NO_INTR

INTERVENE - the user has requested an intervention so that a change to the course of the simulation can be made.

COMPLETE - the simulation has completed.

FATAL_ERROR - the executive has detected an error and cannot continue.

NO_INTR - No interrupt has occurred.

ORGANIZATION (if file):

NOTES:

NAME: INTERVENTIONS

ALIASES:

TYPE: DATA ELEMENT | DATA FLOW| FILE

DESCRIPTION: These are events or actions that interrupt, change, and override SCENARIO conditions only.

COMPOSITION:

ORGANIZATION (if file):

NOTES:

NAME: MENU

ALIASES:

TYPE: DATA ELEMENT | DATA FLOW| FILE

DESCRIPTION: This is the set of selectable options that are displayed for the user.

COMPOSITION:

ORGANIZATION (if file):

NOTES:

NAME: MN_AGAIN

ALIASES:

TYPE: DATA ELEMENT| DATA FLOW | FILE

DESCRIPTION: This is a flag indicating whether MOTHER_NATURE modules are to be called again to continue their calculation.

COMPOSITION: TRUE | FALSE

ORGANIZATION (if file):

NOTES:

NAME: MN_EVENT_PARAMETERS

ALIASES:

TYPE: DATA ELEMENT | DATA FLOW | FILE

DESCRIPTION: This is a file that contains parameters describing all EVENT requests from MOTHER_NATURE submodules. It is used to construct one or more EVENTs to exercise some or all of the MOTHER_NATURE submodules.

COMPOSITION: {SV_CLASS_ID + NEXT_TIME}

ORGANIZATION (if file):

NOTES:

NAME: MN_GEOGRAPHY

ALIASES:

TYPE: DATA ELEMENT | DATA FLOW | FILE

DESCRIPTION: This is a temporary file that stores the GEOGRAPHY information needed by the Grid Quantity Calculation modules.

COMPOSITION:

ORGANIZATION (if file):

NOTES:

NAME: MN_GEOGRAPHY_REQUEST

ALIASES:

TYPE: DATA ELEMENT | DATA FLOW| FILE

DESCRIPTION: This identifies the type and extent of GEOGRAPHY information needed by a particular GRID_QUANTITY calculator, all done in MOTHER_NATURE.

COMPOSITION:

ORGANIZATION (if file):

NOTES:

NAME: MN_SOURCES

ALIASES:

TYPE: DATA ELEMENT | DATA FLOW | FILE

DESCRIPTION: This is a temporary file that stores the source STATE_VECTORs needed by the GRID_QUANTITY calculation modules.

COMPOSITION:

ORGANIZATION (if file):

NOTES:

NAME: MODE

ALIASES:

TYPE: DATA ELEMENT| DATA FLOW | FILE

DESCRIPTION: Mode defines the particular conflict resolution in which a module is supposed to execute in.

COMPOSITION: INSTANT | FIRST_STEP | STEP | LAST_STEP | PARTIAL

INSTANT - execute the instantaneous module

FIRST_STEP - put an event in the EVENT_Q to start the first step

of a conflict resolution. A step event is generated but no calculations are done.

STEP - execute the module from the last time run to the present time and put an event in the EVENT_Q to initiate the next step of the conflict resolution.

LAST_STEP - complete execution of the extended event and do not put a step event in the queue.

PARTIAL - execute the module from the last time run to the present time. No step event is generated.

ORGANIZATION (if file):

NOTES:

NAME: MODULE_LIBRARY

ALIASES:

TYPE: DATA ELEMENT | DATA FLOW | FILE

DESCRIPTION: These are the various versions of the code modules as maintained by the SOURCE CODE CONTROL SYSTEM. The user may select the modules appropriate to a given simulation.

COMPOSITION:

ORGANIZATION (if file):

NOTES:

NAME: MODULE_NAME

ALIASES:

TYPE: DATA ELEMENT| DATA FLOW | FILE

DESCRIPTION: This is the standard format text module name. This is the FORTRAN name.

COMPOSITION:

ORGANIZATION (if file):

NOTES:

NAME: MSG_CODE

ALIASES:

TYPE: DATA ELEMENT| DATA FLOW | FILE

DESCRIPTION: This is a message code in text that can be used to further identify the message or warning or error.

COMPOSITION:

ORGANIZATION (if file):

NOTES: This can be used as an index by a program or as a reference to find a more detailed explanation of an error or message.

NAME: MSG_TEXT

ALIASES:

TYPE: DATA ELEMENT| DATA FLOW | FILE

DESCRIPTION: This is a standard format text string with human-readable message.

COMPOSITION:

ORGANIZATION (if file):

NOTES:

NAME: NEXT_TIME

ALIASES:

TYPE: DATA ELEMENT| DATA FLOW | FILE

DESCRIPTION: This is the next time at which some specified function is to be done.

COMPOSITION:

ORGANIZATION (if file):

NOTES:

NAME: NEW_SOURCE

ALIASES:

TYPE: DATA ELEMENT| DATA FLOW | FILE

DESCRIPTION: This is a logical variable denoting presence of new interference sources that can affect a communication.

COMPOSITION: TRUE | FALSE

ORGANIZATION: (if file):

NOTES:

NAME: OBJECT_TYPE

ALIASES:

TYPE: DATA ELEMENT| DATA FLOW | FILE

DESCRIPTION: Part of EVENT_DATA, this parameter denotes which type of object is to be generated by GENERATE_OBJECT.

COMPOSITION:

ORGANIZATION (if file):

NOTES:

NAME: ORDER_OF_BATTLE

ALIASES:

TYPE: DATA ELEMENT | DATA FLOW| FILE

DESCRIPTION: This is the initial order of battle including equipment and forces.

COMPOSITION:

ORGANIZATION (if file):

NAME: ORIENTATION

ALIASES:

TYPE: DATA ELEMENT | DATA FLOW| FILE

DESCRIPTION: The orientation of an object deformed by, for example, Euler angle.

COMPOSITION:

ORGANIZATION (if file):

NOTES:

NAME: OUTPUT_LOG

ALIASES:

TYPE: DATA ELEMENT | DATA FLOW | FILE

DESCRIPTION: This is a text file containing periodic code and simulation information and all error and warning messages. This will have all user commands and massages that appear on the DISPLAYS data definitions. All errors, warnings, and actions taken will be included in a time-ordered manner. Also included in this description might be a set of files - one for each side in a battle simulation and one for the overall simulation run.

COMPOSITION: {ERROR_MSG} + {WARNING_MSG} + {DISPLAYS}

ORGANIZATION (if file):

NOTES: All processes write into this file as required. It in general is not shown on the data flow diagrams because it makes them too complicated.

NAME: PACKET (generic)

ALIASES:

TYPE: DATA ELEMENT | DATA FLOW| FILE

DESCRIPTION: This is the generic form of the messages that are transmitted from asset to asset.

COMPOSITION: INFO_PTR + XMIT_ID + RCVR_ID + INFO_DATA

ORGANIZATION (if file):

NOTES: There will be many different formats of the data fields for the various assets.
XMIT_ID and RCVR_ID are the SV_ID's for the transmitter and receiver, respectively. See SV_ID for more information.

NAME: PATH_FUNCTIONS

ALIASES:

TYPE: DATA ELEMENT | DATA FLOW | FILE

DESCRIPTION: Path functions are time- and frequency-dependent functions that describe the transformations of TRANSMITTED_PACKET(s) into INCIDENT_PACKET(s).

COMPOSITION:

ORGANIZATION (if file):

NOTES:

NAME: PERCEIVED_ATTRIBUTES

ALIASES:

TYPE: DATA ELEMENT | DATA FLOW| FILE

DESCRIPTION: These are parameters ''measured" by a sensor for each object detected.

COMPOSITION:

ORGANIZATION (if file):

NOTES:

NAME: PERCEIVED_OBJECT_ATTRIBUTES

ALIASES:

TYPE: DATA ELEMENT | DATA FLOW | FILE

DESCRIPTION: This is the local file containing the results of a SENSOR's observations. The information contained in it is processed to construct an INFO_PACKET.

COMPOSITION:

ORGANIZATION (if file):

NOTES:

NAME: PERCEIVED_WORLDS

ALIASES:

TYPE: DATA ELEMENT | DATA FLOW | FILE

DESCRIPTION: This is the perception of the world as seen by the combatants and the assets belonging to the combatants.

COMPOSITION: BATTLE_ORDER +
#combatants #assets
{ { ({ STATE_VECTOR})
+ ({ RECORDED_OBSERVATION})
+ ({ RECORDED_DECISION})
+ ({ ATTACK_PLAN })
+ ({ PLANNED_RESPONSE })
+ ({ BATTLE_MGR_DIRECTIVE }) } }
+ ENVIRONMENT

ORGANIZATION (if file): The boundaries in this file are absolute. For example, no asset can look directly at another asset's PERCEIVED_WORLDS. Spies are an exception to this.

NOTES:

NAME: PHYSICAL_OUTPUT

ALIASES:

TYPE: DATA ELEMENT | DATA FLOW | FILE

DESCRIPTION: This is the hardcopy (e.g., film, paper, etc.) output available to the user.

COMPOSITION: DISPLAYS

ORGANIZATION (if file):

NOTES:

NAME: PLANNED_RESPONSE

ALIASES:

TYPE: DATA ELEMENT | DATA FLOW | FILE

DESCRIPTION: This is the pre-planned response of a combattant to an attack.

COMPOSITION:

ORGANIZATION (if file):

NOTES:

NAME: POSITION

ALIASES:

TYPE: DATA ELEMENT| DATA FLOW | FILE

DESCRIPTION: This is the location of an object.

COMPOSITION:

ORGANIZATION (if file):

NOTES: It may be necessary to carry position in multiple coordinate systems
to allow more efficient calculations.

NAME: POST_PROCESSING

ALIASES:

TYPE: DATA ELEMENT | DATA FLOW | FILE

DESCRIPTION: These are the raw data collected during a simulation run that
may be reduced and analyzed following the run.

COMPOSITION:
{REAL_WORLD} + {PERCEIVED_WORLDS} + {SCENARIO}
+ {EVENT_Q} + {CODE_DATA} + {SIM_DATA}
+ {INFO_PACKETS}

ORGANIZATION (if file):

NAME: PREV_TIME

ALIASES:

TYPE: DATA ELEMENT| DATA FLOW | FILE

DESCRIPTION: This is the time at which the previous simulation calculation
or activity took place for an event.

COMPOSITION:

ORGANIZATION (if file):

NOTES:

NAME: REAL_WORLD

ALIASES:

TYPE: DATA ELEMENT | DATA FLOW | FILE

DESCRIPTION: This is the world as it actually and precisely exists. There are no errors in the real world.

COMPOSITION:
{STATE_VECTOR} /* for all assets */
+ ENVIRONMENT + CONSTANTS /* e.g., pi, speed of light, etc. */
+ GEOGRAPHY

ORGANIZATION (if file):

NOTES:

NAME: RECEIVED_PACKET

ALIASES:

TYPE: DATA ELEMENT | DATA FLOW| FILE

DESCRIPTION: This is a communication packet that is delivered by the receiver. It is the INCIDENT_PACKET modified by the receiver transfer function. For a perfect receiver, it is identical to the INCIDENT_PACKET.

COMPOSITION: PACKET

ORGANIZATION (if file):

NOTES:

NAME: RECEIVER_ID

ALIASES:

TYPE: DATA ELEMENT| DATA FLOW | FILE

DESCRIPTION: This data element identifies the particular communications receiver to which a packet is sent.

COMPOSITION:

ORGANIZATION (if file):

NOTES: This is a SV_ID

NAME: RECORDED_DECISION

ALIASES:

TYPE: DATA ELEMENT | DATA FLOW | FILE

DESCRIPTION: This is a recorded decision made by some particular battle manager.

COMPOSITION:

ORGANIZATION (if file):

NOTES:

NAME: RECORDED_OBSERVATION

ALIASES:

TYPE: DATA ELEMENT | DATA FLOW | FILE

DESCRIPTION: This is a recorded perception of some particular sensor.

COMPOSITION:

ORGANIZATION (if file):

NOTES:

NAME: REF_LIBRARY

ALIASES:

TYPE: DATA ELEMENT | DATA FLOW | FILE

DESCRIPTION: These are the various versions of the DETEC data base as maintained by the SOURCE CODE CONTROL SYSTEM. The data base consists of physical constants, geography, asset descriptions, etc...

COMPOSITION:

ORGANIZATION (if file):

NOTES:

NAME: RESTART_DUMPS

ALIASES:

TYPE: DATA ELEMENT | DATA FLOW | FILE

DESCRIPTION: This is a file containing all data necessary to resume a simulation run as if it had not been interrupted.

COMPOSITION:

{ {SCENARIO} + {REAL_WORLD} + {PERCEIVED_WORLDS}
+ {EVENT_Q} + {INFO_PACKETS} + {CODE_DATA}
+ {IN_PROGRESS} + {PATH_FUNCTIONS} }

ORGANIZATION (if file):

NOTES:

NAME: SAVE_SV

ALIASES:

TYPE: DATA ELEMENT | DATA FLOW | FILE

DESCRIPTION: This is a flag which indicates whether a state vector must be saved if changed.

COMPOSITION: TRUE | FALSE

TRUE - save state vector
FALSE - do not save state vector

ORGANIZATION (if file):

NOTES:

NAME: SCENARIO

ALIASES:

TYPE: DATA ELEMENT | DATA FLOW | FILE

DESCRIPTION: This is the predefined series of actions, events, and constraints that drive and control the simulation.

COMPOSITION:

#combatants
{ (ATTACK_PLAN) + (PLANNED_RESPONSE) }
+ (INTERVENTIONS) /* Events and changes which are used to trigger natural and omnipotent actions */
+ (ORDER_OF_BATTLE)

ORGANIZATION (if file):

NOTES: This defines intent of the plans, combatant assets and status, times of launch, and battle-manager instructions and constraints. Interventions are sometimes referred to as acts of God.

NAME: SCENARIO_LIBRARY

ALIASES:

TYPE: DATA ELEMENT | DATA FLOW | FILE

DESCRIPTION: These are the various scenarios that are saved and maintained by the SOURCE CODE CONTROL SYSTEM.

COMPOSITION:

ORGANIZATION (if file):

NOTES:

NAME: SENSOR_OPERATING_PARAMETERS

ALIASES:

TYPE: DATA ELEMENT | DATA FLOW| FILE

DESCRIPTION: This is information describing parameters such as threshold and frequency range to be used for the SENSOR operations. It is extracted from EVENT_DATA.

COMPOSITION:

ORGANIZATION (if file):

NOTES:

NAME: SIM_DATA

ALIASES:

TYPE: DATA ELEMENT | DATA FLOW | FILE

DESCRIPTION: This information gives the state or status of the simulated battle(s).

COMPOSITION: This is the binary machine representation of data the user had requested for processing into the POST_PROCESSING and RESTART_DUMPS files.

ORGANIZATION (if file):

NOTES: This is very closely related to SIM_STATUS in that the user has requested to log simulation data here in a machine form where SIM_STATUS is in a text user-readable form.

NAME: SIM_STATUS

ALIASES:

TYPE: DATA ELEMENT | DATA FLOW| FILE

DESCRIPTION: This is the status of the simulated battle(s) as displayed for the user.

COMPOSITION: This is text representation of simulation data that the user has requested to view either in DISPLAYS and/or OUTPUT_LOG

ORGANIZATION (if file):

NOTES: See SIM_DATA for clarification of the differences between SIM_STATUS and SIM_DATA.

NAME: SOURCE

ALIASES:

TYPE: DATA ELEMENT| DATA FLOW | FILE

DESCRIPTION: This identifies the module that originated the message, data, or function.

COMPOSITION:

ORGANIZATION (if file):

NOTES:

NAME: STATE_VECTOR (generic)

ALIASES:

TYPE: DATA ELEMENT | DATA FLOW | FILE

DESCRIPTION: This is the standard definition of an object's position, velocity, status, and all other existing parameters.

COMPOSITION:

SV_ID + POSITION + ORIENTATION + SV_CLASS_ID
+ DAMAGE + SV_... + SAVE _SV

ORGANIZATION (if file):

NOTES:

NAME: SV_CLASS_ID

ALIASES:

TYPE: DATA ELEMENT| DATA FLOW | FILE

DESCRIPTION: This is an alphanumeric identifier for each class of STATE_VECTORs. A class may be defined as all STATE_VECTORs that follow the same algorithm for normal (undisturbed) time evolution but may have different values for parameter used in the algorithm. These parameters are part of each STATE_VECTOR.

COMPOSITION:

ORGANIZATION (if file):

NOTES:

NAME: SV_ID

ALIASES:

TYPE: DATA ELEMENT| DATA FLOW | FILE

DESCRIPTION: This is a unique identification for a state vector.

COMPOSITION:

ORGANIZATION (if file):

NOTES:

NAME: SYSTEM_TABLES

ALIASES:

TYPE: DATA ELEMENT | DATA FLOW | FILE

DESCRIPTION: This is a file accessed to change or retrieve the status of the DETEC code within the CTSS system. This will be implemented by library calls to the appropiate system function.

COMPOSITION: System parameters (to be defined as required)

ORGANIZATION (if file):

NOTES:

NAME: TEXT_MSG

ALIASES:

TYPE: DATA ELEMENT | DATA FLOW| FILE

DESCRIPTION: This is the standard format text message designed for human undestanding.

COMPOSITION: DATE_TIME + MODULE_NAME + MSG_CODE + MSG_TEXT

ORGANIZATION (if file):

NOTES:

NAME: TIME

ALIASES:

TYPE: DATA ELEMENT| DATA FLOW | FILE

DESCRIPTION: This is the binary time as maintained by the simulation program.

COMPOSITION:

ORGANIZATION (if file):

NOTES:

NAME: TRANS_CHARACTERISTICS

ALIASES:

TYPE: DATA ELEMENT | DATA FLOW| FILE

DESCRIPTION: This data flow describes the characteristics of a communications transmitter, such as frequency band, power distribution function, power level, etc.

COMPOSITION:

ORGANIZATION (if file):

NOTES:

NAME: TRANSMITTED_PACKET

ALIASES:

TYPE: DATA ELEMENT | DATA FLOW| FILE

DESCRIPTION: This is the communications packet that was actually transmitted. It is the INTENDED_PACKET modified by transmitter transfer function. For a perfect transmitter, it is identical to the INTENDED_PACKET.

COMPOSITION: PACKET

ORGANIZATION (if file):

NOTES:

NAME: TRANSMITTER_ID

ALIASES:

TYPE: DATA ELEMENT| DATA FLOW | FILE

DESCRIPTION: This data element identifies the particular communications transmitter that sends a packet.

COMPOSITION:

ORGANIZATION (if file):

NOTES: This is a SV_ID

NAME: VIEWABLE_OBJECT_LIST

ALIASES:

TYPE: DATA ELEMENT | DATA FLOW | FILE

DESCRIPTION: This is a file containing IDs of the STATE_VECTOR of all objects determined to be viewable by the Filter.

COMPOSITION: {SV_ID}

ORGANIZATION (if file):

NOTES:

NAME: WARNING_MSG

ALIASES:

TYPE: DATA ELEMENT | DATA FLOW| FILE

DESCRIPTION: This is an information message describing a possibly abnormal condition.

COMPOSITION: TEXT_MSG

ORGANIZATION (if file):

NOTES:

9. APPENDIX

A. STRUCTURED ANALYSIS CONVENTIONS

B. NAMING CONVENTIONS

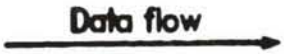
C. ALTERNATIVE PROPOSALS

Reference: Structured Analysis and System Specification

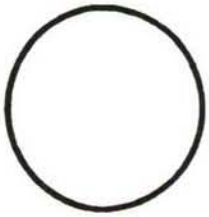
by Tom De Marco

Data Flow Notation:

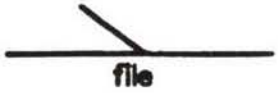
Data source
or sink



Data flow

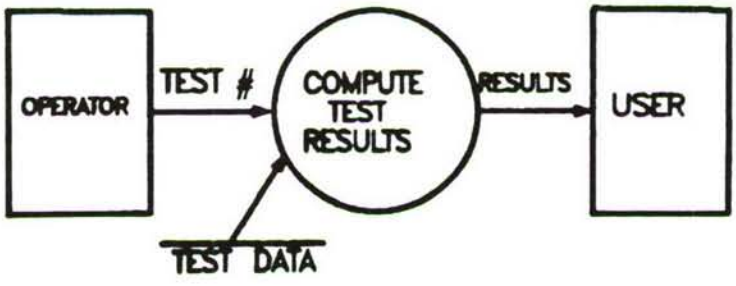


data transform or process – input data
are transformed into output data.



a file – data storage

Data Flow Example:



The test data for the specified test number are taken from the file and transformed into results.

Data Dictionary Notation:

= means "is equivalent to"

+ means "and"

[ ] means "either–or" i.e., select one of the options

{ } means "iterations of" the component enclosed

( ) means the enclosed component is "optional"

| means "or"

Data Dictionary Examples:

COMMAND = [START | STOP | ABORT]

– select one of the options

DATA–BASE = {SHOT–DATA + SHOT–NUMBER + (SUBSYSTEM–ID)}

–the data base consists of multiple sets of shot data and shot number and an optional subsystem identification.

APPENDIX B. NAMING CONVENTIONS

BM - battle-manager process
CM - communications process
CMD - command
EG - engagement
ENV - environment
EP - event physics process
EQ - event queue file
EV - event
EX - executive process
IN - in progress file
INTEL - intelligence
IP - information packet
LG - logger process
MN - mother nature process
MR - manager process
PF - path functions file
PP - postprocessing file
PTR - pointer
PW - perceived world file
Q - queue
RD - restart dumps file
RW - real-world file
SC - scenario file
SN - sensor process
SV - state vector
WP - weapons process

APPENDIX C. ALTERNATIVE PROPOSALS

This is an alternative proposal for the Executive conflict handler.

```
 1  ------------------------
 2  CONHAN - CONFLICT HANDLER
 3  ------------------------
 4  DEFINITIONS -
 5    TI = Initial time for CONHAN search
 6    TH = Time horizon for CONHAN search
 7    TB = Begin time for extended event
 8    TE = End time for extended event
 9    TET = Temporary end time for extended event
10    TC = Check time
11    TCP = Previous check time
12    TM = First mismatch time in EVENT Q comparison
13    CHK = Check event
14    SCH = Search event
15    ITP = Interval type flag
16    Interval types are:
17      AF = Asset Function (ITP=AF)
18      EP = Event Physics  (ITP=EP)
19    LBL = Interval label
20    Ai = Set of labels for EP intervals that overlap AF
21         intervals, for asset i.
22    Bi = Set of labels for responsive EP intervals,
23         for asset i.
24    Responsiveness of an EP interval implies that EP acting
25    upon asset i has the potential of creating new events
26    within the EP interval.
27
28  FUNCTION - This module searches the interval [TI,TH] in the
29    EVENT_Q for conflict events and establishes conflict
30    process control by setting state vector flags and spawning
31    new events. This is accomplished by using set theory.
32  ------------------------------------------------------------
33  CONHAN (EVENT_PTR)
34    /* Compare EVENT_Q with EVENT_Q_OLD over [TCP,TC] */
35    IF (CHK AND EVENT_Q = EVENT_Q_OLD), THEN
36      TCP = TC
37    ELSE
38      IF (SCH), THEN
39        TI = TH
40        TCP = TI
41        CALCULATE NEXT TIME HORIZON (TH)
42        INSERT SCH IN EVENT_Q
43        INSERT CHK(S) IN EVENT_Q
44      ELSE
45        FIND TM
```

```
46          TI = TM
47        END IF
48        WRITE EVENT_Q FOR [TI,TH] IN EVENT_Q_OLD
49        SEARCH [TI,TH] FOR EVENTS THAT HAVE ASSETS IN COMMON
50        /* Scan to horizon */
51        DO FOR EACH ASSET (i)
52          TET =   TE
53          IF (TH < TE), THEN
54            TET = TH
55          END IF
56          COMPUTE TIME INTERVAL [TB,TET]
57          ASSIGN INTERVAL TYPE AND LABEL (ITP,LBL)
58          CHECK FOR OVERLAP OF TIME INTERVALS AND LOAD Ai
59          CHECK COUPLING MATRIX FOR RESPONSIVENESS AND LOAD Bi
60          IF (Ai OR Bi), THEN
61            FURTHER INTERVAL TESTS  /* May not be necessary! */
62            SET CONFLICT FLAGS IN EVENT_DATA (ITP)
63          END IF
64        END DO
65      END IF
66    RETURN
67
```

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